WATER TUBE BOILERS

WIDDER & MILLER COMPANY
N. E. Representatives
141 Milk St., Boston, Mass.
Phone MAIN 1255

ESTABLISHED 1864

E. KEELER COMPANY
WILLIAMSPORT, PA.

We also manufacture

HORIZONTAL RETURN TUBULAR BOILERS

A. S. M. E., Massachusetts, or special requirements

Bulletin upon request

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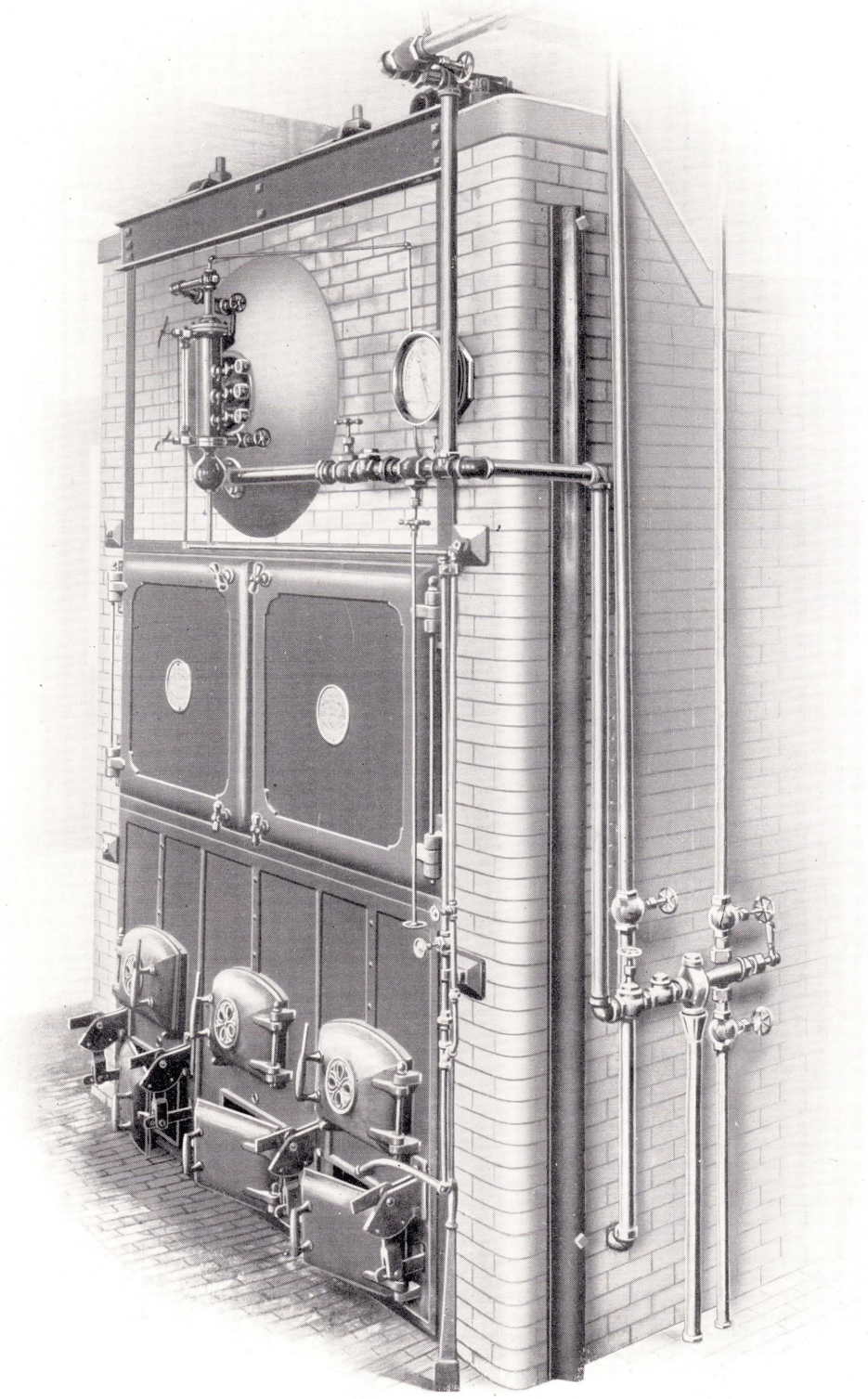


UNITED STATES BUREAU OF STANDARDS, PIERCE MILL ROAD,
WASHINGTON, D. C., 250 H. P. BOILER WITH AJAX GRATES

INTRODUCTORY

THE Keeler Water Tube Boiler is offered to discriminating steam users as the product of over fifty years experience in constructing boilers of all standard types.

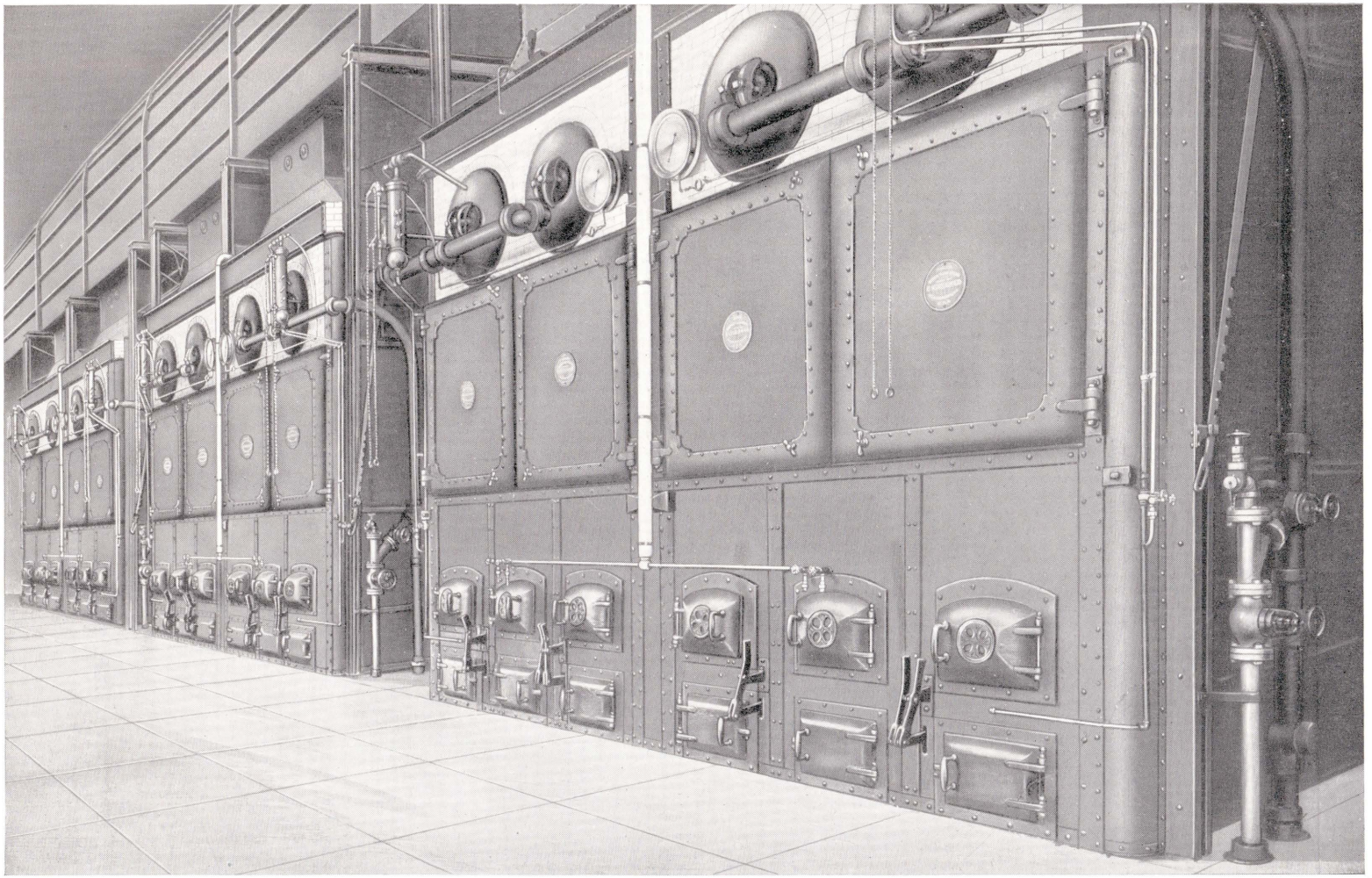
Keeler Quality is the result of a consistent effort to place Keeler Boilers among purchasers who require the best that can be produced. To interest such purchasers we have met low price competition by improvements in design and refinements of workmanship which more than equal any difference in first cost in a few years of reliable service.

The character of the equipment shown in the following pages is partly the result of careful observation of each part or fixture in actual service.

There is no feature of any boiler in the market today that is any more efficient or reliable than a similar feature of the Keeler Water Tube Boiler.

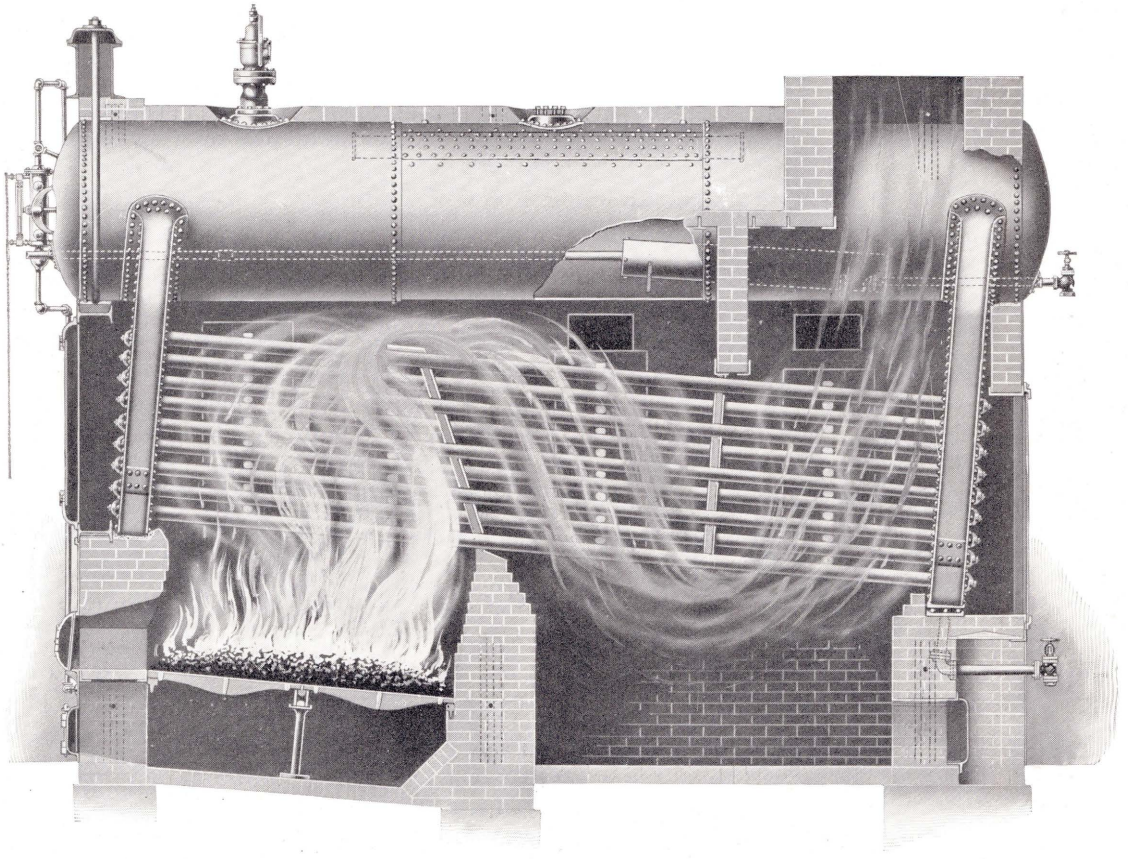
The extreme care used in the construction of these boilers can only be appreciated by a visit to our shop or by an inspection of the completed work.

A thoroughly modern shop equipment, a progressive policy, and long experience enables the E. Keeler Company to meet the requirements of the most exacting specifications.



ISTHMIAN CANAL COMMISSION AT GATUN, CANAL ZONE, SIX 410 H. P. BOILERS. DUPLICATE PLANT AT MIRAFLORES, CANAL ZONE. BOILERS EQUIPPED FOR OIL FUEL WITH ALTERNATE EQUIPMENT OF AJAX SHAKING GRATES FOR COAL.

The Keeler Water Tube Boiler, Standard Type



GENERAL DESCRIPTION—The Keeler Water Tube Boiler presents an unusually complete combination of features that have been widely recognized as valuable. This boiler was designed to secure simplicity and durability of construction together with absolute safety and the highest obtainable economy.

The general arrangement follows well tried lines of practice. The boiler consists of one or more steam and water drums to which are securely riveted a front and rear water leg or header. The tubes are expanded into these headers in straight horizontal and staggered vertical rows with an inclination of one inch to the foot. The drum is horizontal providing a maximum steam disengaging surface. The steam outlet is placed in the center of the drum.

Vertical baffle walls of a special grade of fire brick with a backing of cast iron direct the gases three times through the bank of tubes. The tubes are staggered and the gases move at right angles to them. They are thus continually divided and reunited and brought into intimate contact with the tube surfaces. With vertical baffles special side cleaning doors are provided with separate openings opposite each space between tubes, admitting no cold air when the soot blower is inserted.

Horizontal baffles can be provided if required by special conditions of fuel or service. Other special arrangements of baffle walls are offered when it is desired to take the gases from the bottom of the setting at the rear.

The arrangement of furnace, tubes, headers and drum in the Keeler Water Tube Boiler is efficient, accessible and compact.

The superior efficiency of the Keeler Boiler rests upon correct proportions of heating and grate surface for the character of fuel to be burned, ample height of furnace, a superior arrangement of baffle walls and a perfect circulation.

Every portion of the heating surface is accessible for both external and internal inspection making it impossible for soot or scale to accumulate undetected. There is ample room between tubes and drum for inspection or repairs. Special side cleaning doors make it possible to observe the condition of the outside surface of the tubes. There is no part of the interior surface that cannot be examined and cleaned.

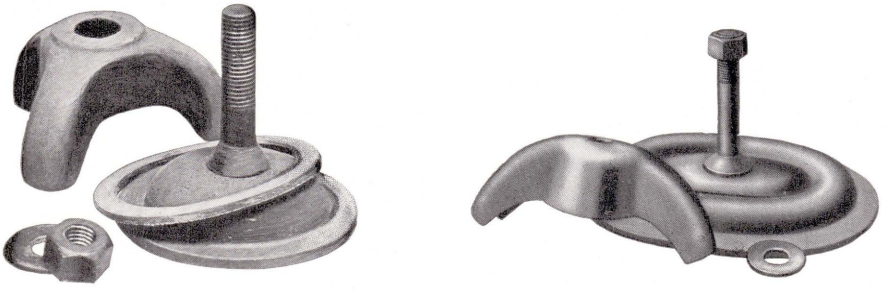
By opening a few hand-holes in the front header, a cleaning hose may be inserted into the ends of all adjacent tubes, the scale being removed through the bottom row of holes in the rear header. For purpose of inspection, a candle attached to a wire may be lowered into the rear header from the drum. As it is held at the end of each tube in turn, it is possible to note the condition of the surface without removing the rear hand-holes.

If hard scale forms in the tubes it is still unnecessary to remove any but the bottom row of rear hand-holes, and those in front. The sediment is scraped off and pushed back into the rear header where it may be removed through the lower hand-holes.

Space conditions where buildings have already been designed or erected usually demand a compact boiler. There is no arrangement of vertical or semi-vertical tubes that compares favorably with the Keeler Boiler in this respect.

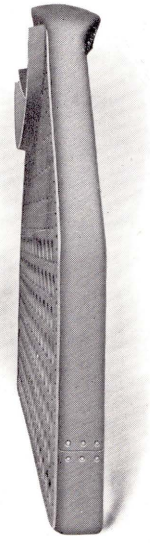
Keeler Water Tube Boilers are usually built complete and tested in the shop. This reduces the cost of erection, as the boilers are handled as a unit. It also eliminates the dangers due to careless assembling of boilers in the field and makes the erection merely a matter of placing in position and attaching fittings.

Boilers of 500 H. P. and more must be shipped in a knocked down condition. We are prepared to send erecting engineers to any part of the country to rivet the drums to the headers, expand the tubes and test.



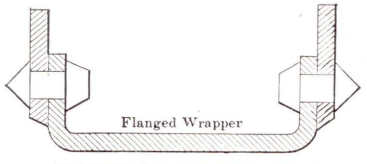
KEELER PRESSED STEEL HAND-HOLE AND MANHOLE PLATES.
PRESSED STEEL YOKES

DETAILS OF CONSTRUCTION



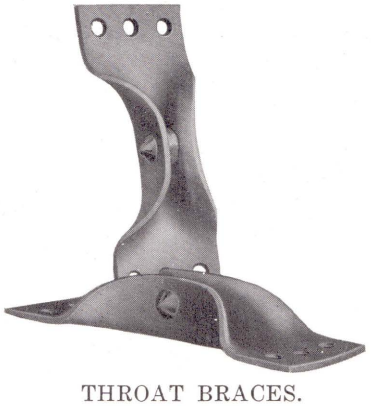
Keeler All Wrought Steel Headers consist of a tube sheet and a hand hole sheet flanged at a single heat to fit the drum and a wrapper sheet flanged to a channel section connecting the tube and hand hole sheet.

Tube Sheets are stayed to the hand hole sheets with stay bolts screwed in, upset and riveted over. Stay bolts are solid with a hole drilled 1¼″ deep in each end unless otherwise specified.



SECTION OF HEADER

The headers are securely riveted to the drum. A series of rectangular openings provides a large area for free and unimpeded circulation between headers and drum. Between openings, bridges of uncut plate are left which are reinforced by special pressed steel braces. Stay bolts are carried close to the drum insuring a large factor of safety at this point.



THROAT BRACES.

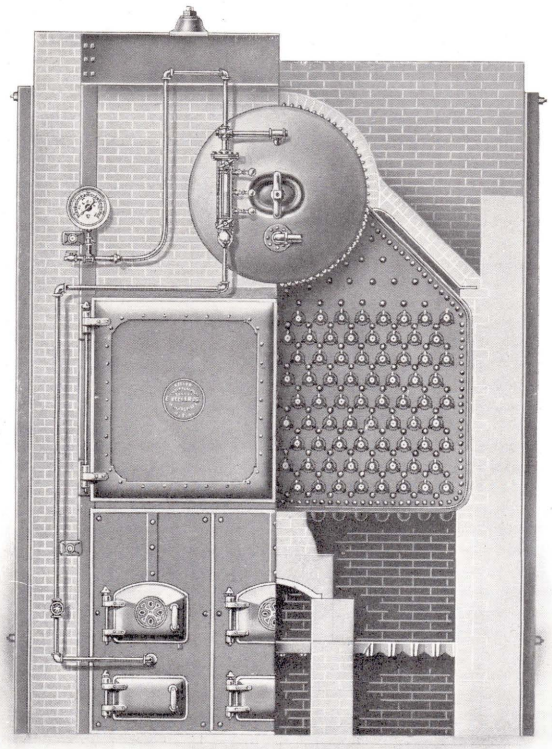
The manhole, usually located in the front head of the drum, is internally flanged and reinforced, with a stiffening ring shrunk on, affording a seat for a gasket about one inch wide. The Manhole Plate, and Hand-hole Plates opposite each end of each tube, are of pressed steel with bolts permanently riveted in position. The plates are on the inside of the header so that increase of pressure tightens the joint and throws no additional strain on the bolt and yoke. They are lighter and easier to handle than cast iron plates with separate bolts and they do not break. Hand-holes are slightly chamfered inside and faced smooth with an emery wheel for the reception of gasket.

DETAILS OF EQUIPMENT

The front and supporting frame consists of I beam columns resting on cast iron foundation plates below the floor line and supporting channel iron girders. The vertical columns are strongly braced by horizontal I beams which form the tube door opening. The whole frame work is rigidly held in place by means of two cast iron washers and tie rods for each wall which extend through the setting to similar washers which hold the rear casing in position.

Tube doors are of cast iron with steel plate centers and bronze name plates. They are hinged to the vertical columns.

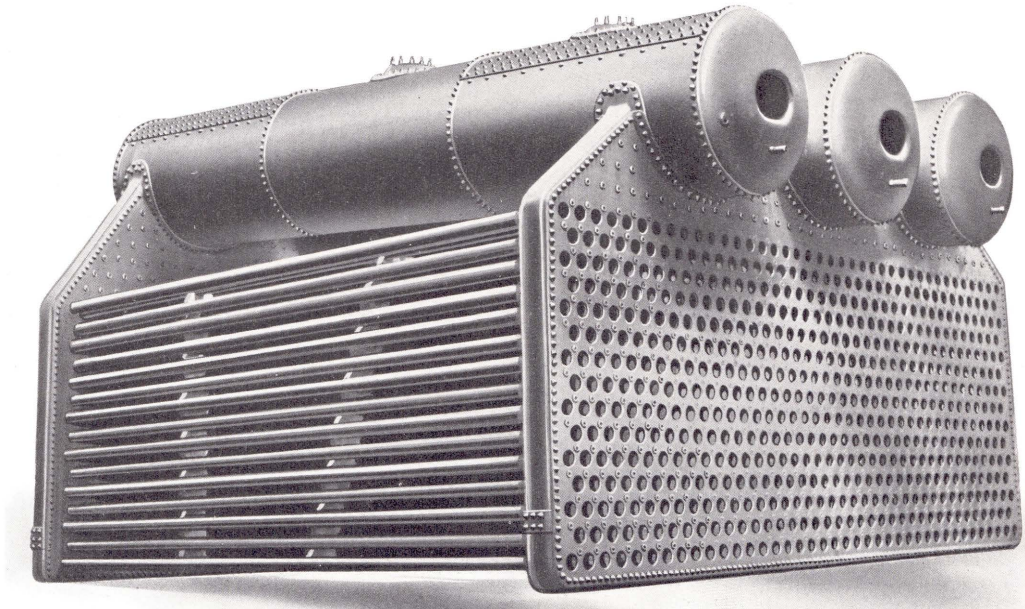
The fire front is a set of removable cast iron panels bolted to the frame work.



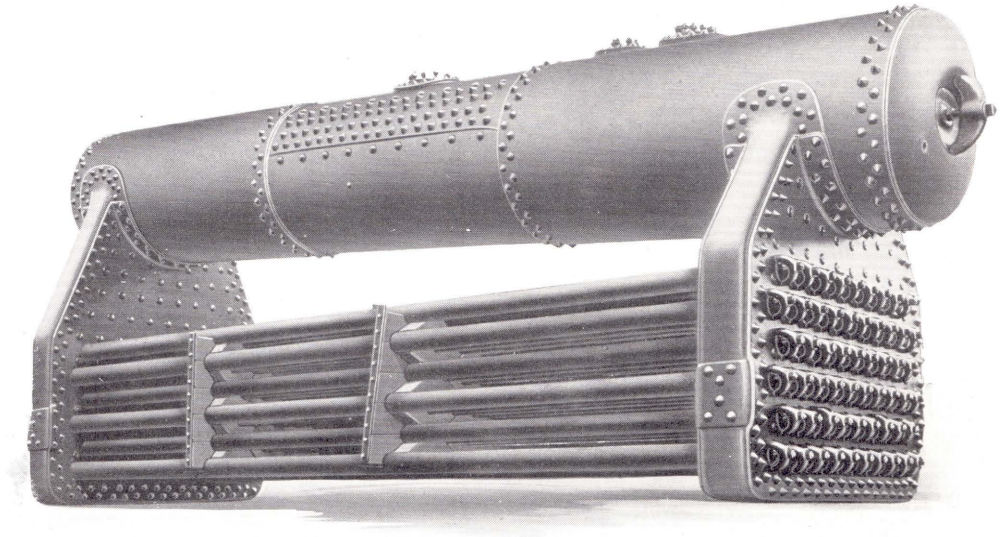
FRONT ELEVATION, HALF SECTIONAL.

All doors have a deep flange or roll. This feature prevents warping and cracking of edges and gives the front a rich and handsome appearance. Fire doors are of an extra heavy, deep pattern with a liberal air space between the door and the perforated liner which preserves both castings. Fire doors close against inclined seats so that they never hang away from the front. There is a separate expansion plate bolted in above the fire doors which absolutely prevents cracks in the front at the corners of the openings under all ordinary conditions of service. All doors and seats are carefully fitted to a close bearing and all fronts are assembled complete before shipment.

FIRE DOOR.



NICHOLS COPPER CO., LAUREL HILL, L. I., N. Y., ONE 1154 H. P. AND ONE 1276 H. P. BOILER, BUILT FOR 220 POUNDS SAFE WORKING PRESSURE.



J. E. LONERGAN CO., PHILADELPHIA, PA., SPECIAL 105 H. P. BOILER, BUILT FOR 350 POUNDS SAFE WORKING PRESSURE.

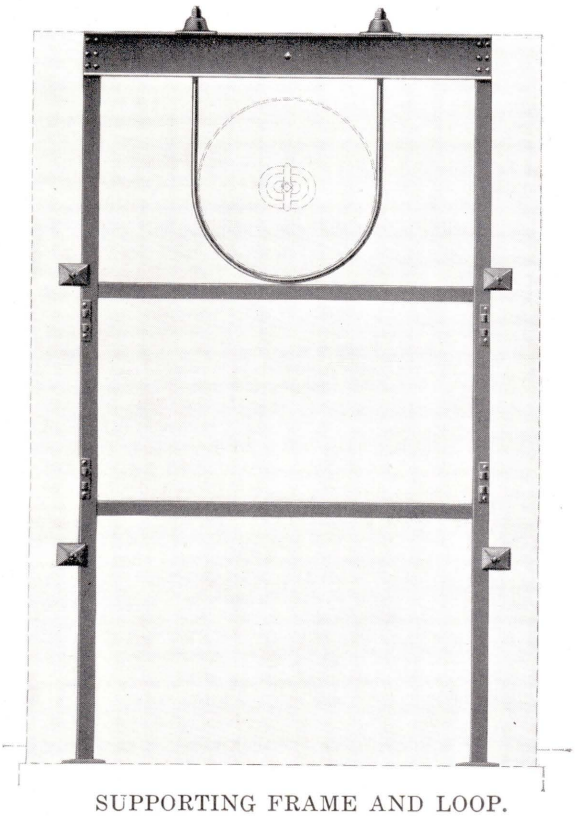
DETAILS OF EQUIPMENT

The ends of the drum are flush with the setting. The front end of the boiler is hung from overhead girders by means of a loop extending under the drum in front of the header where it is not exposed to the fire, thus making the support entirely independent of the side walls of the setting.

Heavy forged spanner yokes are provided across the channel girders from which the loops are hung.

The rear end of the boiler rests on expansion plates and rolls bedded on low brick wall, making perfect provision for expansion and contraction.

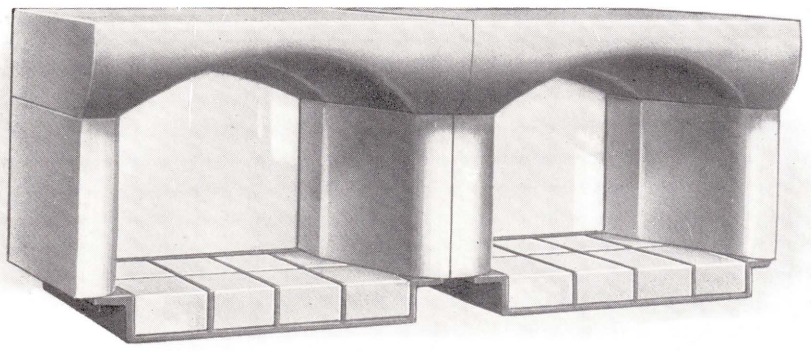
Fire door arches and jambs are single blocks of hard burned fire clay of the most refractory mixture. Both jambs and arches are flared to facilitate spreading the coal.



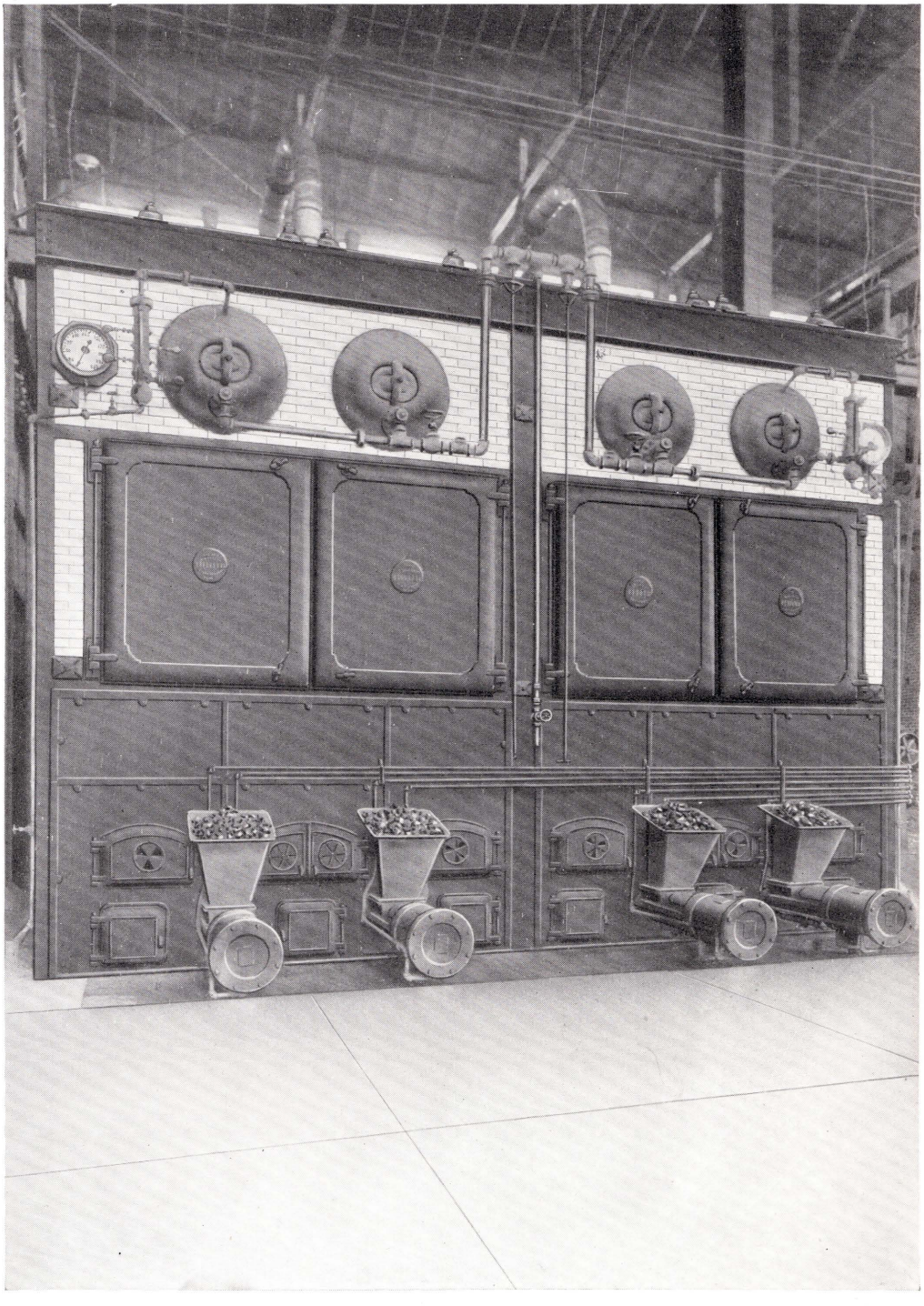
SUPPORTING FRAME AND LOOP.

Dead plates are of a special design arranged for fire brick lining.

Cast iron ribs alternate with the bricks and prevent excessive wear.



DOOR BRICK AND DEAD PLATES.



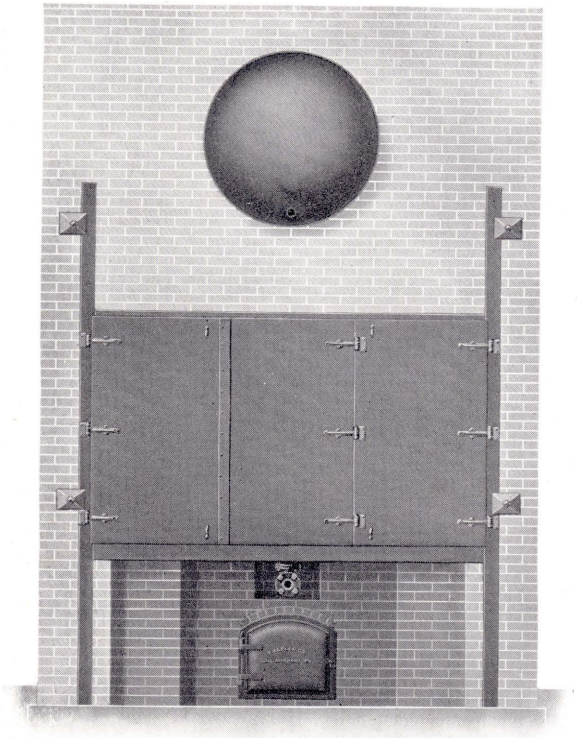
WATER WORKS, CITY OF DUNKIRK, N. Y., TWO 410 H. P. BOILERS, UNDER-FEED STOKERS, INSTALLED 1910. TWO 410 H. P. BOILERS INSTALLED 1915.

DETAILS OF EQUIPMENT

Other special fire brick are provided to enclose the bottom row of rivets in the front header. As the rivets in the vertical seams are built into the side walls of the setting there are no rivets exposed to direct heat of the furnace. Special brick are also provided for the top of the bridge wall and for the edges of the vertical baffle walls. By the use of the brick the baffles are extended 3″ into the setting walls.

Grate bars over 48 inches long are in two sections with heavy center bearing bar. The front end rests on a single bearing bar entirely independent of the dead plate.

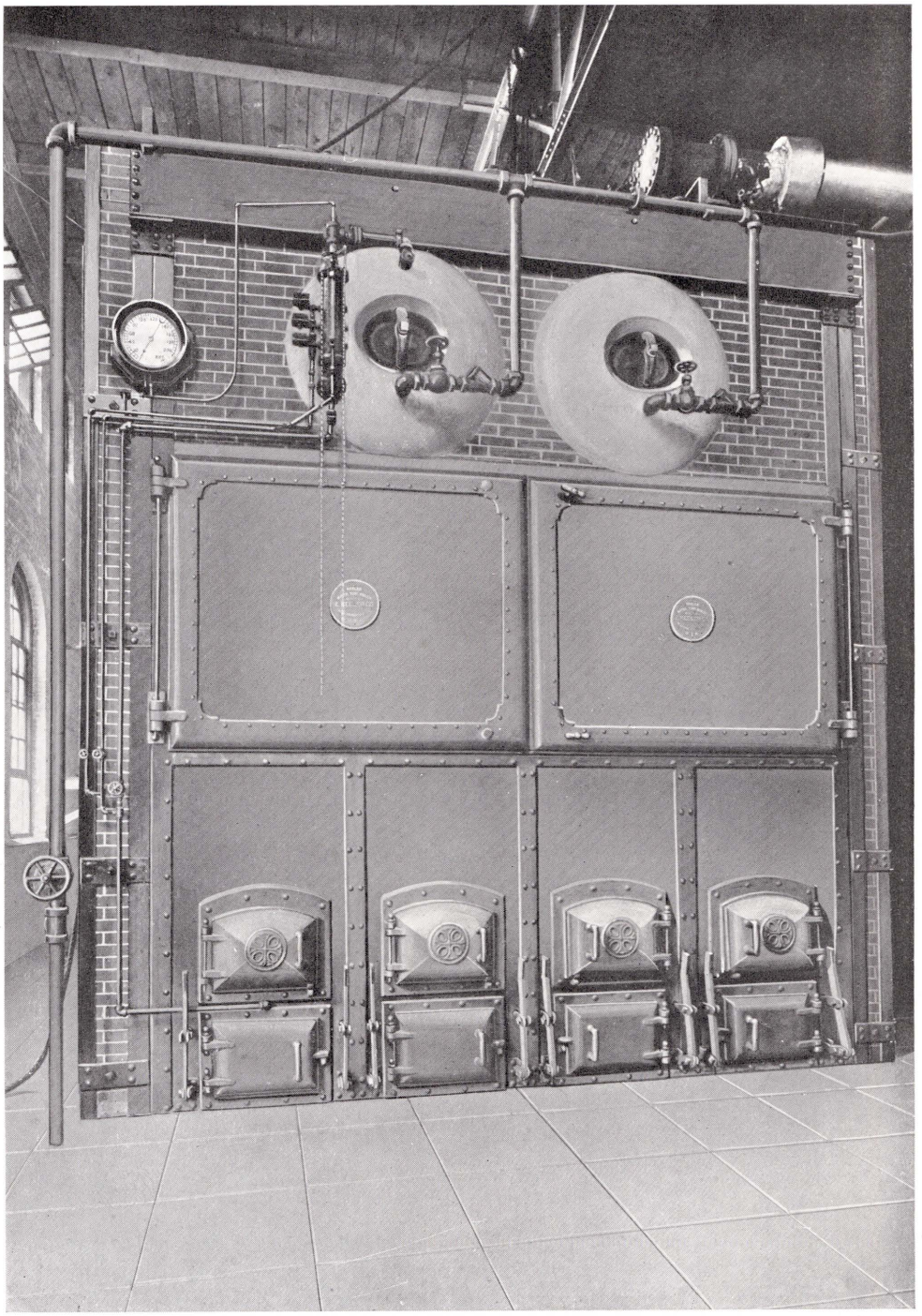
Buckstays for side and rear walls are of Pressed Steel of a section that insures great strength and stiffness. There is no danger of breakage as with cast-iron, and their light weight makes them much more convenient to handle.



REAR CASING.

The rear header is protected from losses by radiation by means of hinged steel doors on an angle iron frame.

This feature, though often omitted by other manufacturers, is a very essential part of the equipment.



NEW YORK CENTRAL & HUDSON RIVER RAILROAD, AVIS SHOPS, AVIS, PA.,
500 H. P. BOILER.

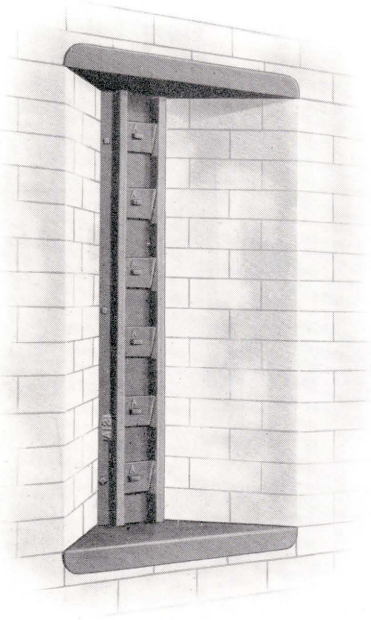
DETAILS OF EQUIPMENT

With vertical baffles, special tube dusting doors are provided for installation in the side walls of the setting. There is a separate opening opposite each space between tubes, and as each lid is opened and closed in turn, practically no cold air is admitted while in use.

When the lids are raised they remain open until a touch from the end of the blower causes them to drop into position and wedge tightly against their seats.

Cast iron lintels are provided for the protection of the brick work at the top and bottom of the openings.

The soot blower with hose and valve completes a perfect equipment for the removal of soot from the tube surfaces.

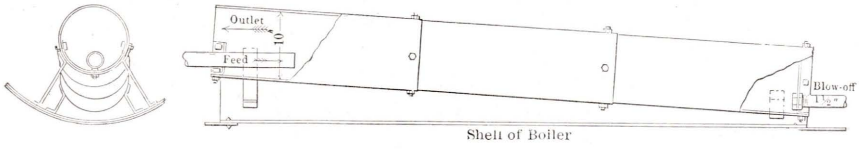


TUBE DUSTING DOORS.

Steam, Safety Valve, and Feed Flanges are pressed from heavy open hearth steel plate. The bottom blow off connection is formed in the bottom plate of the back header in such a way as to prevent the lodging of scale and sediment.

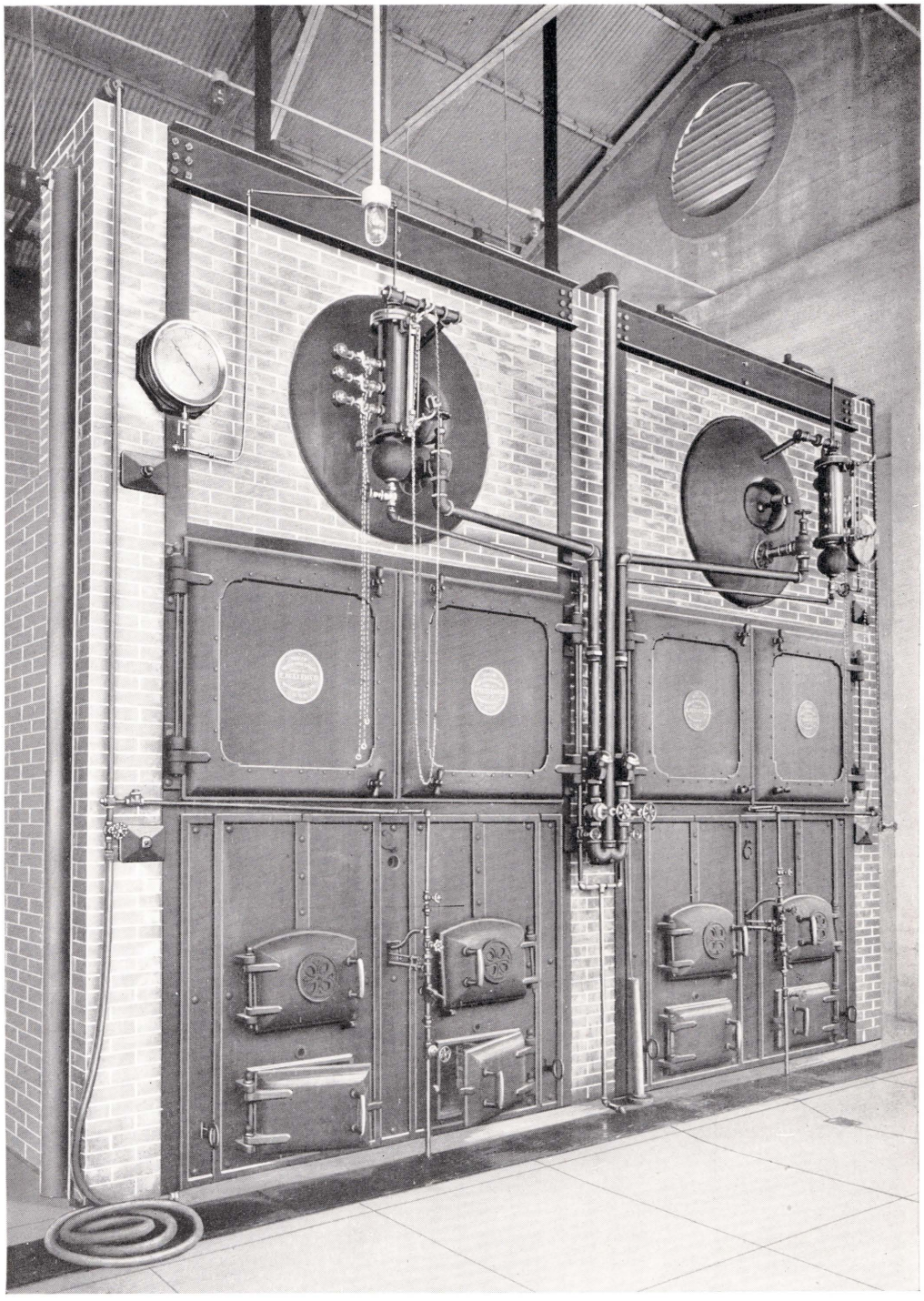
A dry pipe is placed at the steam outlet to prevent the entrainment of water and insure dry steam.

The feed water is introduced through the front head into a submerged sheet steel mud drum. It is heated in its passage through the surrounding water, and before it leaves this drum at the front end is of practically the same temperature as the rest of the water in the boiler. This high temperature causes the pre-



INTERNAL MUD DRUM.

cipitation of most of the impurities in the lower end of the drum to be blown out through the outlet in the rear head provided for that purpose. The internal mud drum also serves to prevent the feed from coming in contact with hot plates, with consequent contraction and leakage at the seams. Any impurities carried into the general circulation are deposited in the bottom of the rear header and discharged through the main blow off openings.



FORT SCOTT, THE PRESIDIO, SAN FRANCISCO, CALIFORNIA, TWO 200 H. P. BOILERS. BOILERS EQUIPPED FOR OIL FUEL.

MATERIALS AND WORKMANSHIP

All plates are of the best Open Hearth flange or fire box steel as required by their location in the boiler. Plates are stamped with the maker's name, brand and tensile strength. Manufacturer's reports showing the physical and chemical properties furnished on request.

All flange steel plates will have a tensile strength of from 55,000 to 65,000 pounds per square inch with a yield point of at least fifty per cent. of the tensile strength. Fire box steel will have a tensile strength of from 55,000 to 63,000 pounds per square inch with a yield point of at least fifty per cent.

Chemical analysis for boiler plates will be in accordance with the requirements of the revised code of the A. S. M. E. Samples to endure bending double without fracture both before and after being brought to red heat and quenched. All plates to be free from injurious surface defects.

All rivets are of special soft rivet steel capable of being bent over double while cold without sign of fracture.

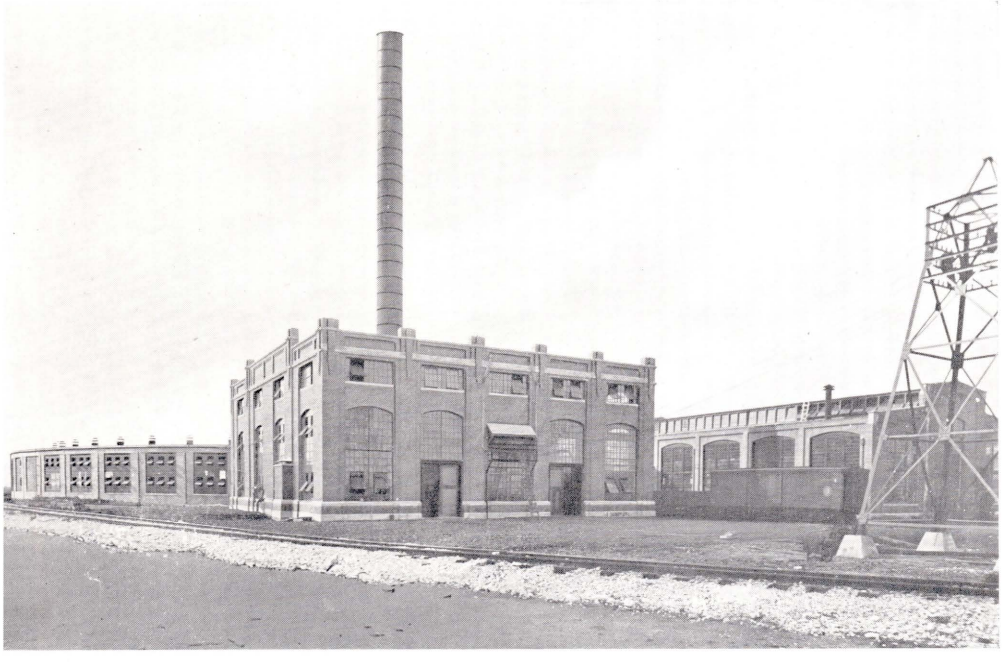
All holes for rivets and staybolts are punched smaller than required and drilled or reamed to size, thus insuring perfect alignment. All burrs are removed before riveting. Rivets are driven wherever possible by heavy hydraulic pressure and held until shrinkage takes place. All other rivets driven by pneumatic hammer. Drums are caulked inside and out with a round nosed tool.

All Tube and Hand Holes are drilled from the solid plate, and edges smoothly chamfered off.

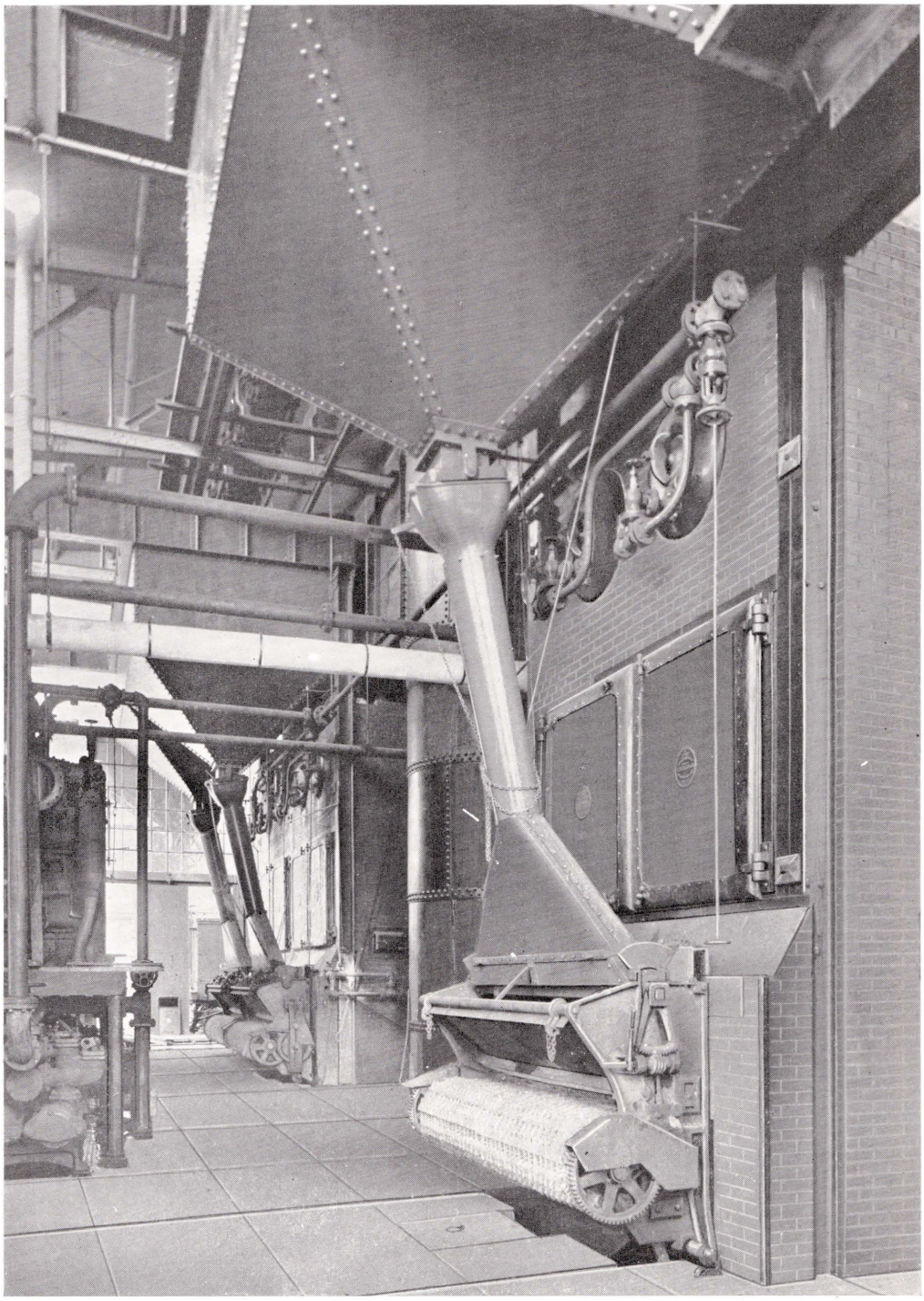
All flanging is done at a uniform heat by hydraulic pressure without hammering.

All boilers tested to a hydrostatic pressure 50 per cent. greater than working pressure.

Boilers are guaranteed to pass the inspection of any established boiler inspection and insurance company for the pressure specified.



POWER HOUSE, PENNSYLVANIA RAILROAD COMPANY,
NORTHUMBERLAND, PA.



PENNSYLVANIA RAILROAD COMPANY, CLASSIFICATION YARD, NORTHUMBERLAND, PA., THREE 410 H. P. BOILERS. CHAIN GRATE STOKERS.

THE ARGUMENT

WROUGHT STEEL for every part of the boiler under pressure is acknowledged to be the first requirement of reliability. Cast iron or cast steel as a material for Water Tube headers, cross boxes, hand hole plates and other parts has proved by an endless list of failures to be uncertain and dangerous.

TUBES—All tubes are straight. Boilers with bent tubes are accepted only as a compromise. The process of bending a tube makes it liable to failure on the outside of the bent portion. A bent tube is harder to keep clean and the interior cannot be inspected. A supply of each kind of tube in the boiler must be carried in stock for repairs. At any distance from the factory express charges would make it impossible to consider purchasing tubes as wanted.

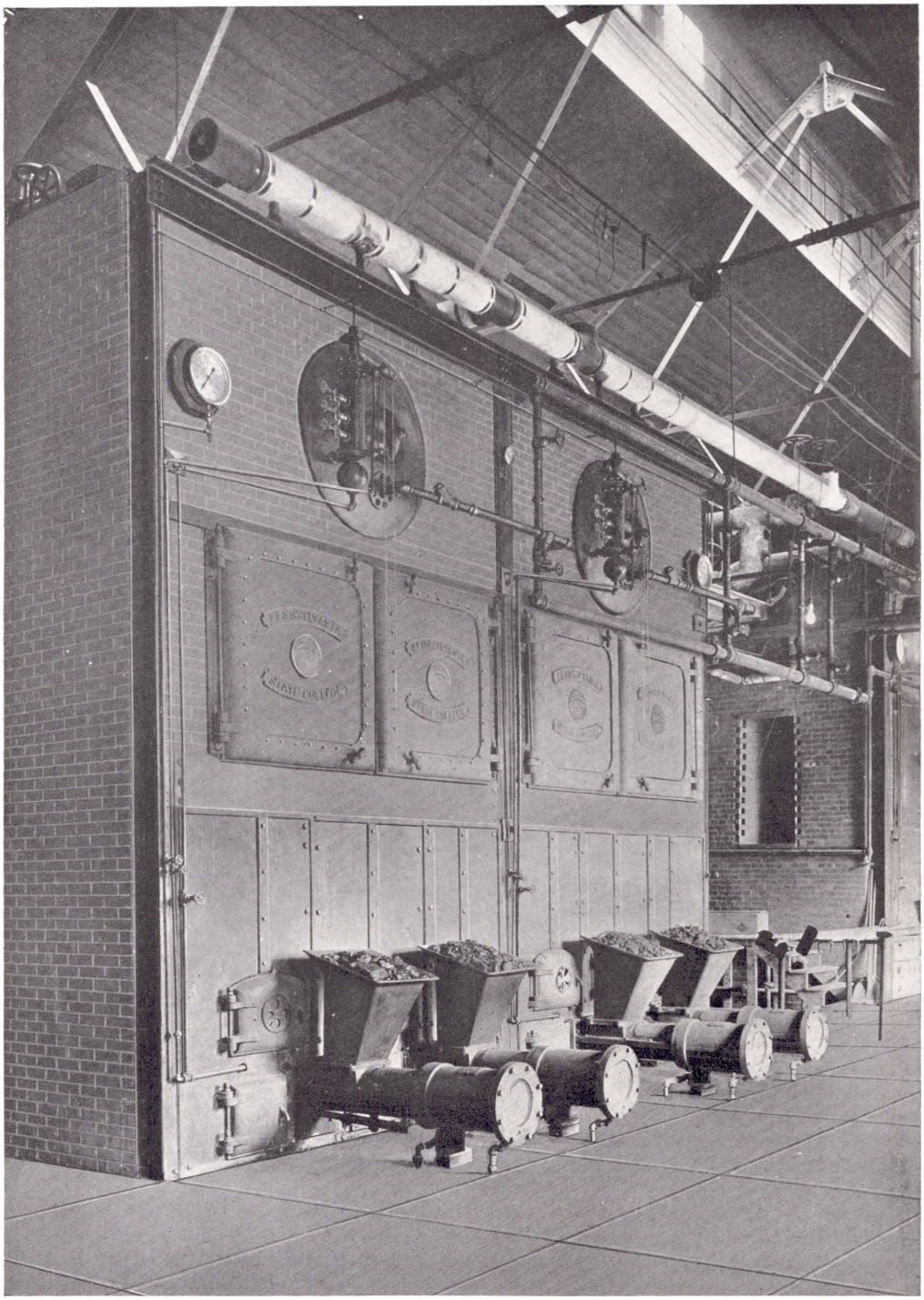
All tubes are four inches in diameter and sixteen or eighteen feet long. This is a standard carried in stock by dealers everywhere. A 4-inch tube is stiffer than a 3½-inch tube in the ratio of 1.52 to 1.04 (their section moduli). Three and one-half inch tubes sag and leak at the headers. Four inch tubes do not.

DRUM—The steam and water drum is placed in a horizontal position so that steam may be taken out at a point removed from the upward rush of steam and water at the front header. If the steam outlet is required at the front end, a dry pipe may be carried back to the center third of the drum. A horizontal drum has a larger disengaging surface, it affords room for inspection of the lower surface, and provides for the most advantageous location of superheaters. A longer rear header also makes a more flexible boiler. By placing the drum horizontal with the ends flush with the setting, provision is made for a perfect arrangement of structural steel framework and supporting loop which passes around the drum in front of the header and out of the path of the hot gases. This arrangement also provides for the most satisfactory location of feed, water column and manhole openings.

HEADERS—A boiler constructed with headers makes possible the most compact arrangement of heating surface, furnace and steam space. Tubes may be cleaned without going inside of a hot boiler. Tubes may be removed in the firing space, while the removal of vertical and semi-vertical tubes sometimes involves the cutting and repairing of a hole in the roof, making permanent or fire-proof building construction impossible over such a boiler.

A built up header affords areas for the circulation of water between tubes and drums far in excess of similiar areas in headers of other types. It is the only method of constructing a header of wrought steel in which the original thickness of material is maintained. In the construction of the Keeler Header the narrow wrapper sheets are flanged to a channel section at one heat. Both the corners and the upper ends which rivet to the drum are formed in dies without hammering. The large tube and hand-hole sheets have one flange which is the work of one heat and one stroke of the press. This method obviates the strains produced when the edges of the large plates are flanged a section at a time to suit a flat wrapper sheet.

Solid stay bolts with drilled ends provide the safety feature of large diameter, hollow stay bolts, without the serious loss by air leakage. These bolts are of thoroughly reliable material and of uniform sectional area. Hollow bolts must be provided with plugs, which are seldom kept in place.



PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PA., TWO 250 H. P. BOILERS, UNDERFEED STOKERS, INSTALLED 1911. ONE 250 H. P. BOILER, TAYLOR STOKER, INSTALLED 1914.

THE ARGUMENT

BAFFLING—In a boiler equipped with vertical baffle the tube surface is divided into three parts: The gases from the furnace flow upward among the tubes in the first pass, downward in the second pass and upward to the smoke flue in the third pass. Horizontal baffles consist of flat tile resting on the top and bottom rows of tubes. There is an opening for the flow of gases of combustion at the rear of the bottom baffle and the front of the top baffle.

The Keeler Boiler can be equipped with either type of baffle or a combination of both. Vertical baffles are recommended because they are more efficient, need practically no repairs, do not collect soot and do not interfere with its removal from the tubes. The cast iron backing of vertical baffle walls is built into the setting and forms a strong support for the tubes. The weight of horizontal baffles and the soot that collects on them together with the excessive heat to which the tubes in the bottom row are exposed causes them to sag and leak at the headers. This effect is especially noticeable where tubes are less than four inches in diameter.

With vertical baffles the heat is more uniformly distributed since the temperature is greatest at the bottom of the first pass and at the top of the second pass.

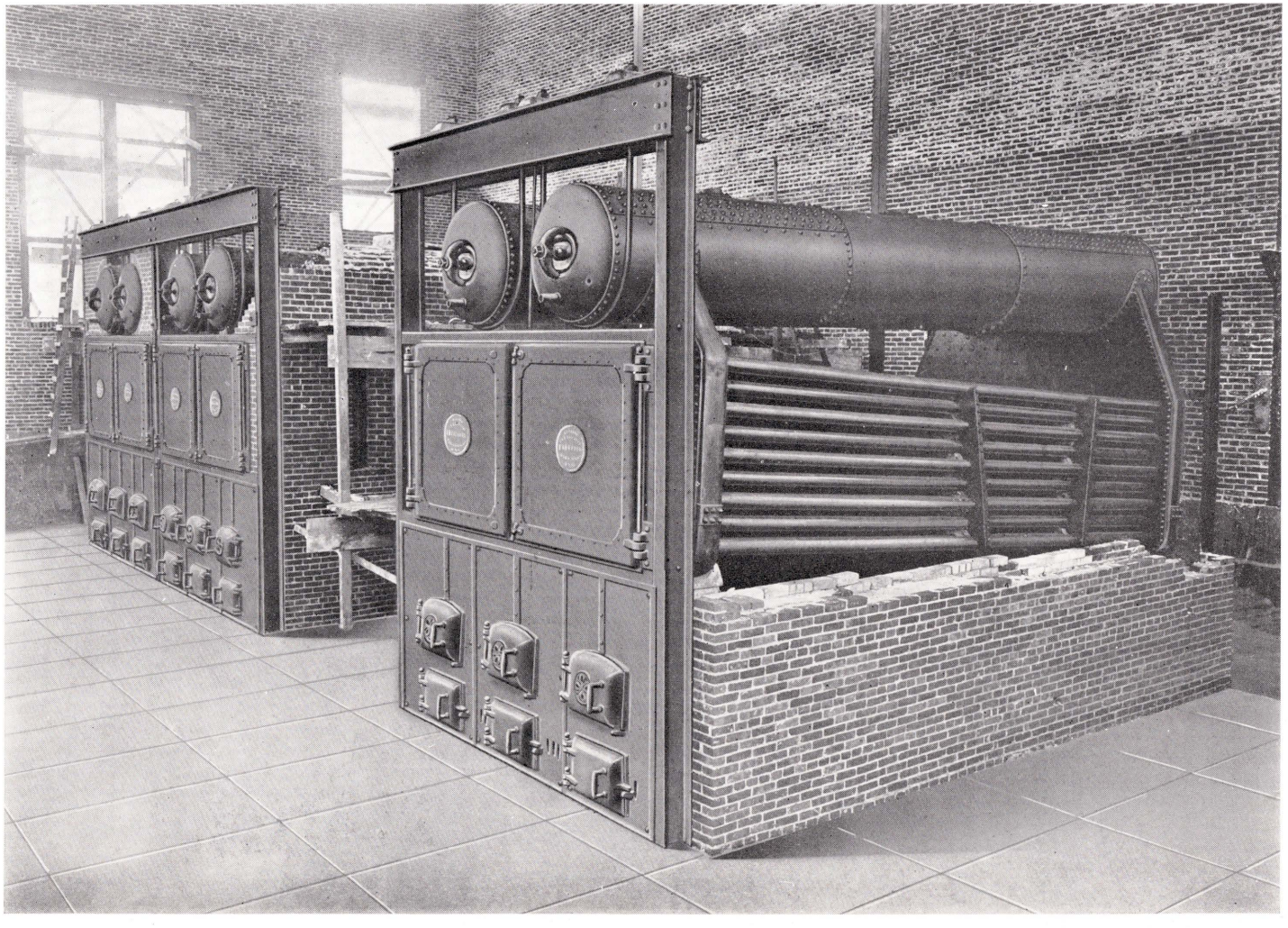
The long combustion chamber obtained by the use of horizontal baffles is an advantage in the use of some fuels, but the benefits sought may be far more perfectly realized by the use of an oven form of setting in connection with vertical baffles.

The superior efficiency of the vertical baffle rests on the fact that the hottest gases are in contact with tubes containing the hottest mixture of steam and water. In the third pass where the gases are considerably cooled the tubes contain a solid body of cooler water. Heat is still absorbed at a rate that is impossible when gases of least temperature are in contact with tubes containing steam and water of greatest temperature.

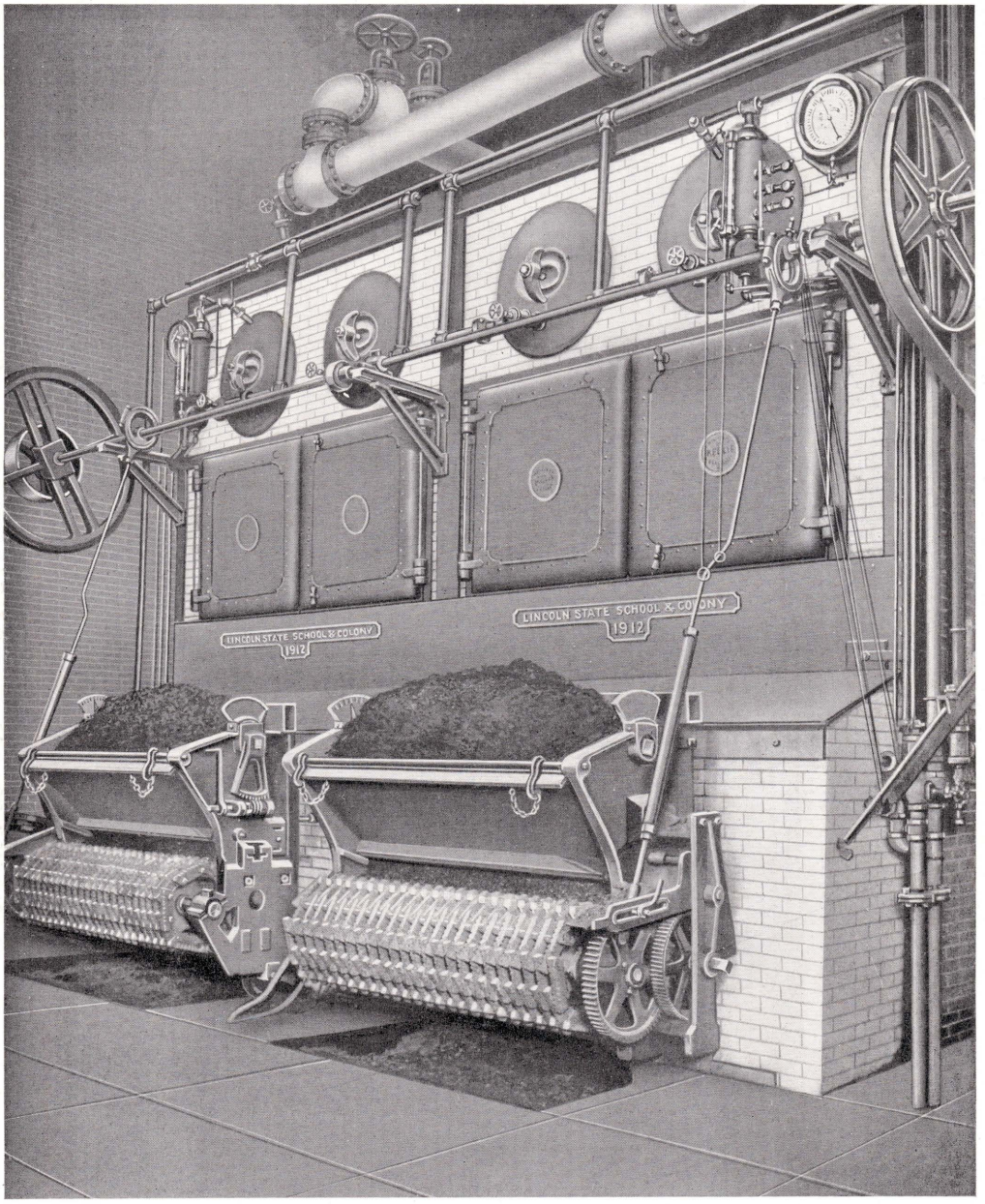
Short circuiting cannot occur in a boiler equipped with vertical baffles. The tubes are staggered and the gases passing between tubes of one row are divided and thoroughly mixed by coming in contact with the tubes in the row above.

Repairs to horizontal baffles must be made many times during the life time of a set of tubes, while vertical baffles will outlast the tubes. Vertical baffles do not interfere with the removing and replacing of tubes.

It is much easier to dislodge soot by blowing across the tubes through small openings in the side wall than to blow it longitudinally the whole length of the horizontal baffle through hollow stay bolts in the front header. Unless a long pipe is used and used faithfully the dust will pile up on the rear end of the bottom baffle. This obstructs the draft and causes the fire to burn out the baffle at the front end. A very small heap of dust at this point will prevent the gases from reaching the clean tube surfaces in front of the obstruction. It is sometimes necessary to dislodge the tile to clean the boiler.

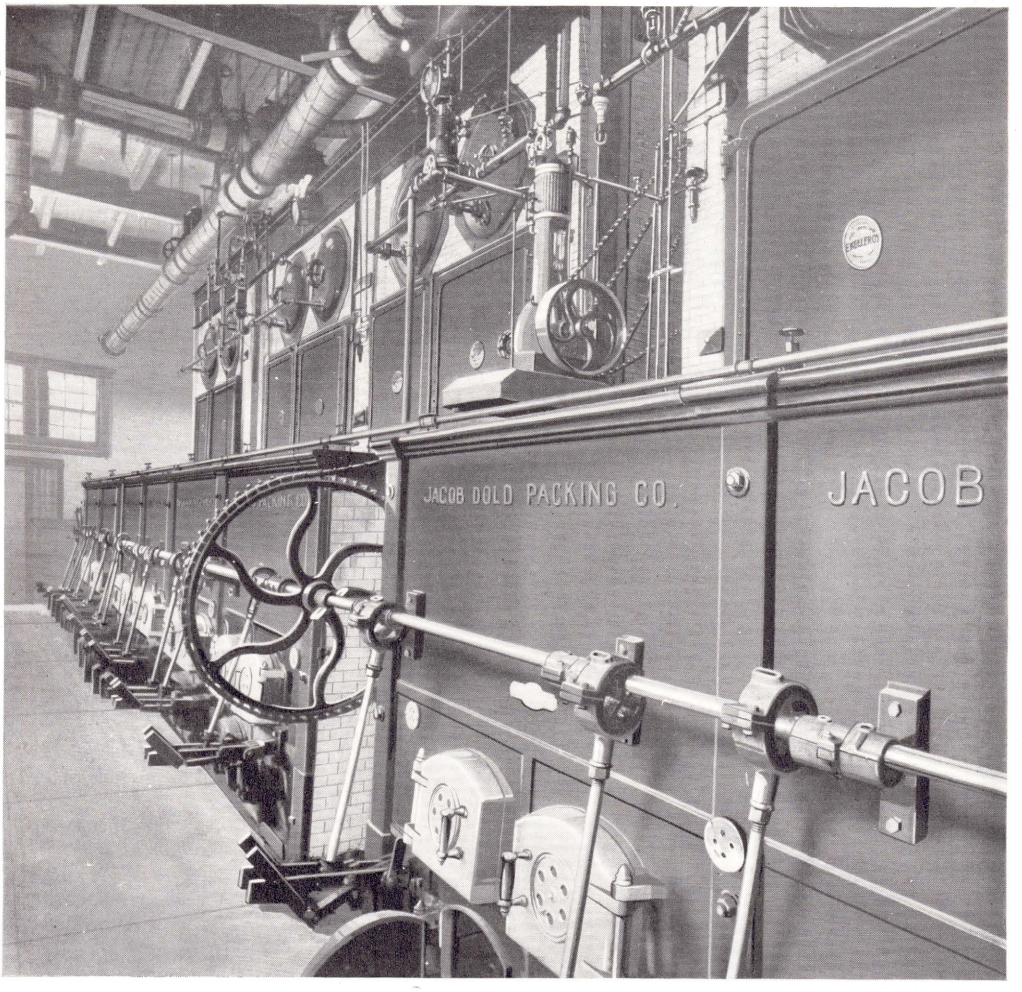


PHILADELPHIA SUBURBAN GAS & ELECTRIC CO., POTTSTOWN, PA., THREE 338 H. P. BOILERS, INSTALLED 1911. ONE 338 H. P. BOILER INSTALLED 1916.



STATE BOARD OF ADMINISTRATION, SPRINGFIELD, ILL.
LINCOLN STATE SCHOOL AND COLONY, LINCOLN, ILL., FOUR 250 H. P.
CHICAGO STATE HOSPITAL, DUNNING, ILL., FOUR 400 H. P., TWO 300 H. P.
ELGIN STATE HOSPITAL, ELGIN, ILL., ONE 400 H. P., TWO 300 H. P.
ALTON STATE HOSPITAL, ALTON, ILL., TWO 400 H. P., TWO 300 H. P.
DIXON STATE HOSPITAL, DIXON, ILL., TWO 400 H. P.
KANKAKEE STATE HOSPITAL, KANKAKEE, ILL., ONE 500 H. P.
ST. CHARLES SCHOOL FOR BOYS, ST. CHARLES, ILL., ONE 400 H. P.

COOK COUNTY INFIRMARY, OAK FOREST, ILL., FIVE 350 H. P. BOILERS INSTALLED 1909. ONE 350 H. P. BOILER INSTALLED 1912. ONE 350 H. P. BOILER INSTALLED 1914. CHAIN GRATE STOKERS.

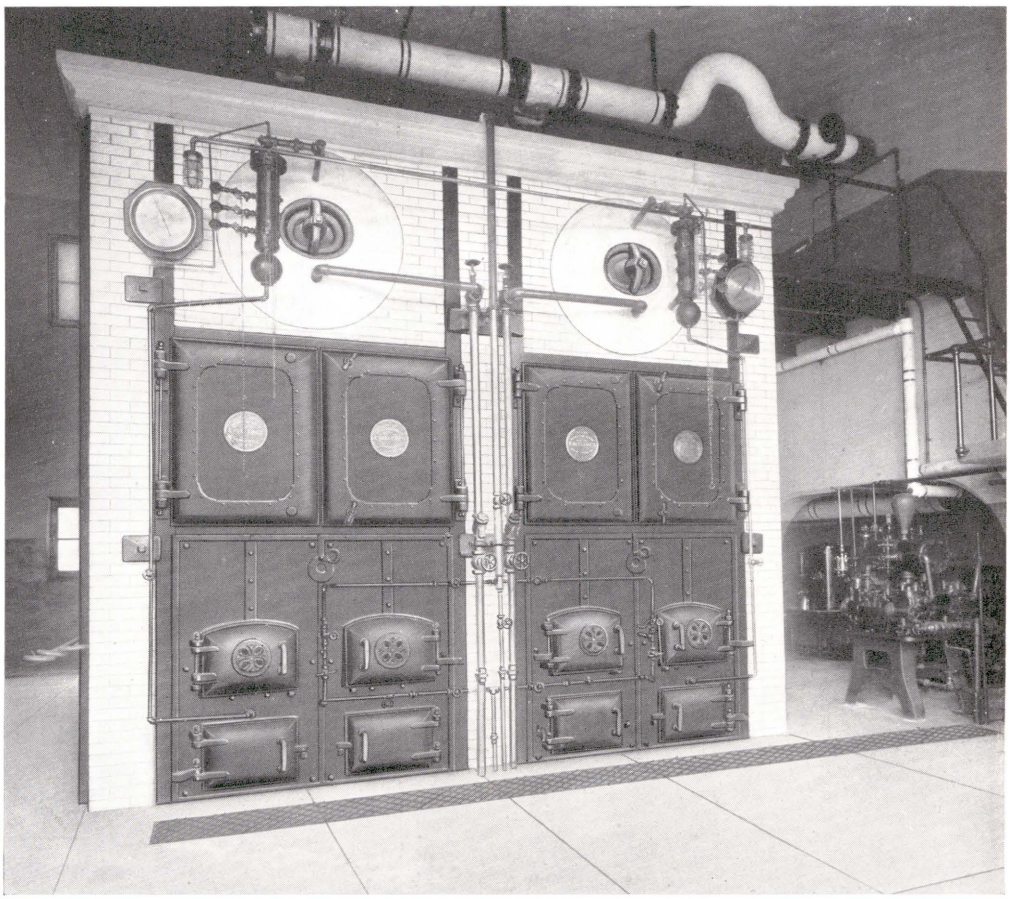


JACOB DOLD PACKING COMPANY, BUFFALO, N. Y., FOUR 535 H. P. BOILERS, EQUIPPED WITH DUTCH OVENS AND AJAX SHAKING GRATES, MECHANICALLY OPERATED.

DRY STEAM

The importance of dry steam cannot be over estimated. Where priming takes place there is not only the danger due to water in the engine cylinder but a continuous loss by reason of particles of water carried with the steam and allowed to pass through the engine without doing useful work. The amount of heat contained in water just at the boiling point is about 26 to 28 per cent. of the total heat contained in the same weight of high pressure steam and the loss of this heat will show a corresponding loss in the efficiency of the plant.

The Keeler Water Tube Boiler delivers dry steam because the steam formed in the tubes is carried to the drum by a rapid and uninterrupted circulation. The horizontal position of the drum affords the maximum area for the quiet separation of steam and water. The horizontal position of the drum makes it possible to locate the steam outlet well back of the upward rush of steam and water at the front header. A dry pipe at the steam outlet assists in the separation and makes it impossible for water to be drawn into the steam mains.



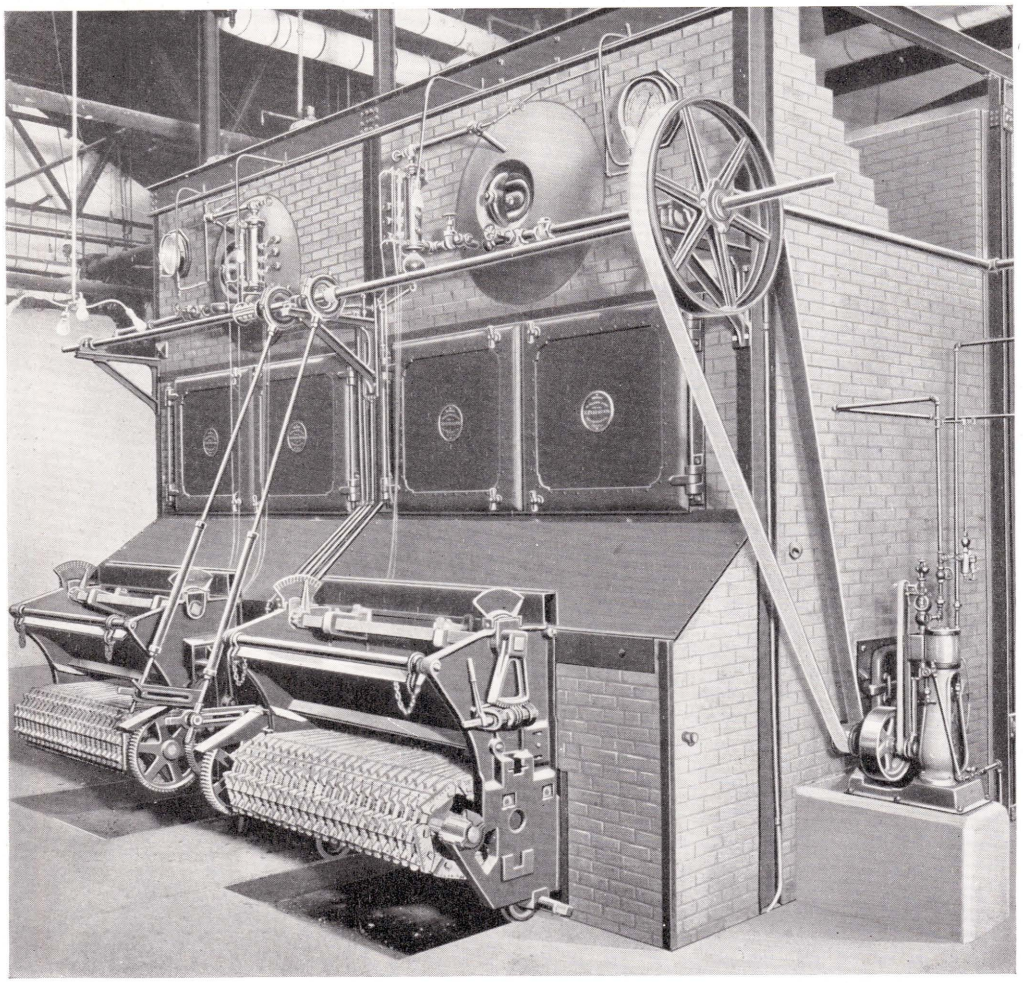
FORT CASEY, NEAR SEATTLE, WASHINGTON, ENGINEERS' CORPS, UNITED STATES GOVERNMENT, TWO 150 H. P. BOILERS. BOILERS EQUIPPED FOR OIL FUEL.

CIRCULATION

A constant and free circulation of water is one of the most important requirements in the design of a water tube boiler. In this vital feature many boilers are deficient.

Sometimes as many as eighteen tubes placed one above the other must draw their supply of water from the drum through a nipple which is no larger than one of them. The small supply of water allowed to reach the bottom tube is converted into steam before it can be replaced and the current of water is driven back upon itself by the expanding steam so that this tube is often practically empty of water.

Deficient circulation is also to be found in boilers where the current of steam and water, instead of passing from header to header through the whole bank of tubes, suffers a loss of head by being compelled by an uncertain mechanical device to traverse one tube after another through return bends. The violent explosive or geyser-like action of steam formed in the lower tubes is not to be compared with the steady, uninterrupted flow of steam and water to be found in the Keeler Boiler.



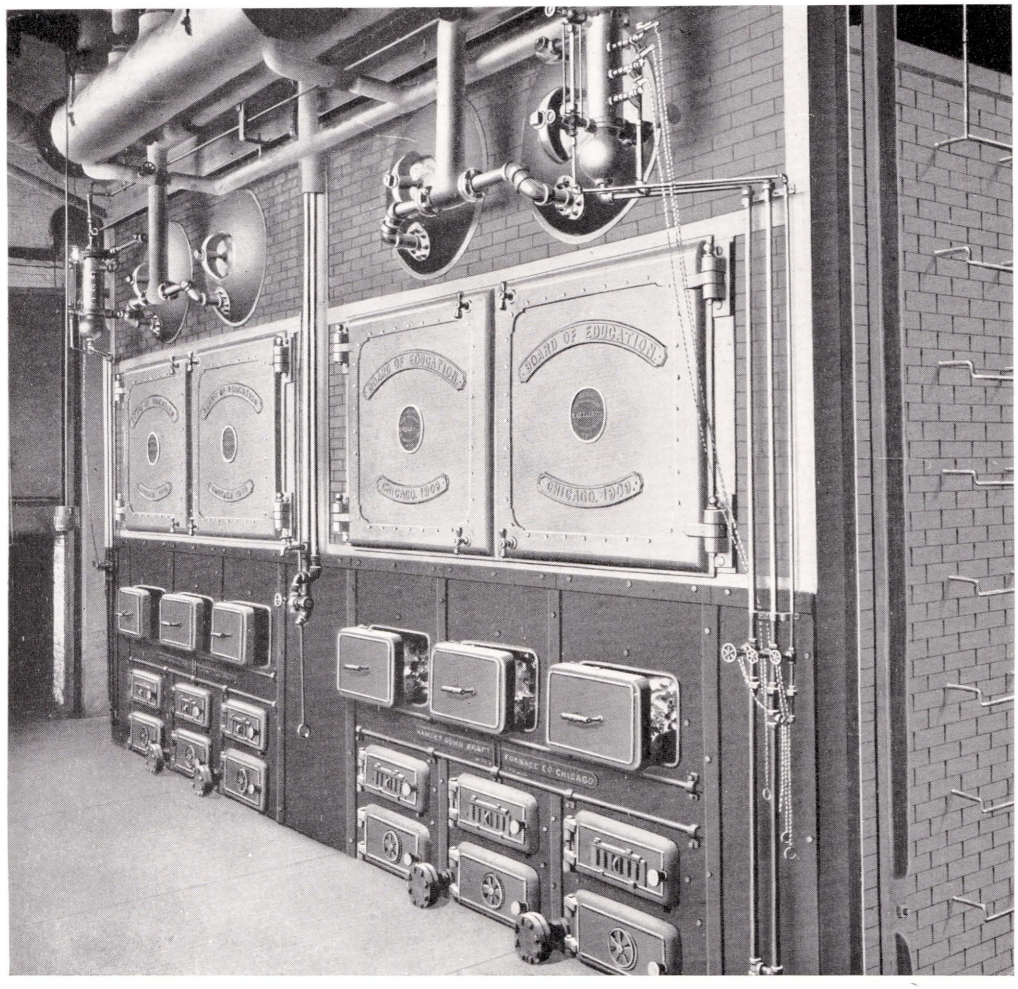
HOUSE OF CORRECTION, CHICAGO, ILL., TWO 250 H. P. BOILERS.
CHAIN GRATE STOKERS.

CIRCULATION

In the Keeler Water Tube Boiler, the difference in density between the body of water in the rear header and the body of mingled steam and water in the tubes and front header causes a positive downward flow to take place in the rear header, the solid body of cooler water continually displacing the hotter body in the tubes and front header. The water passes forward through the whole bank of tubes where it comes in contact with the heat of the furnace and enters the front header. From the header it rises to the drum where ample disengaging surface is provided for the quiet separation of steam and water.

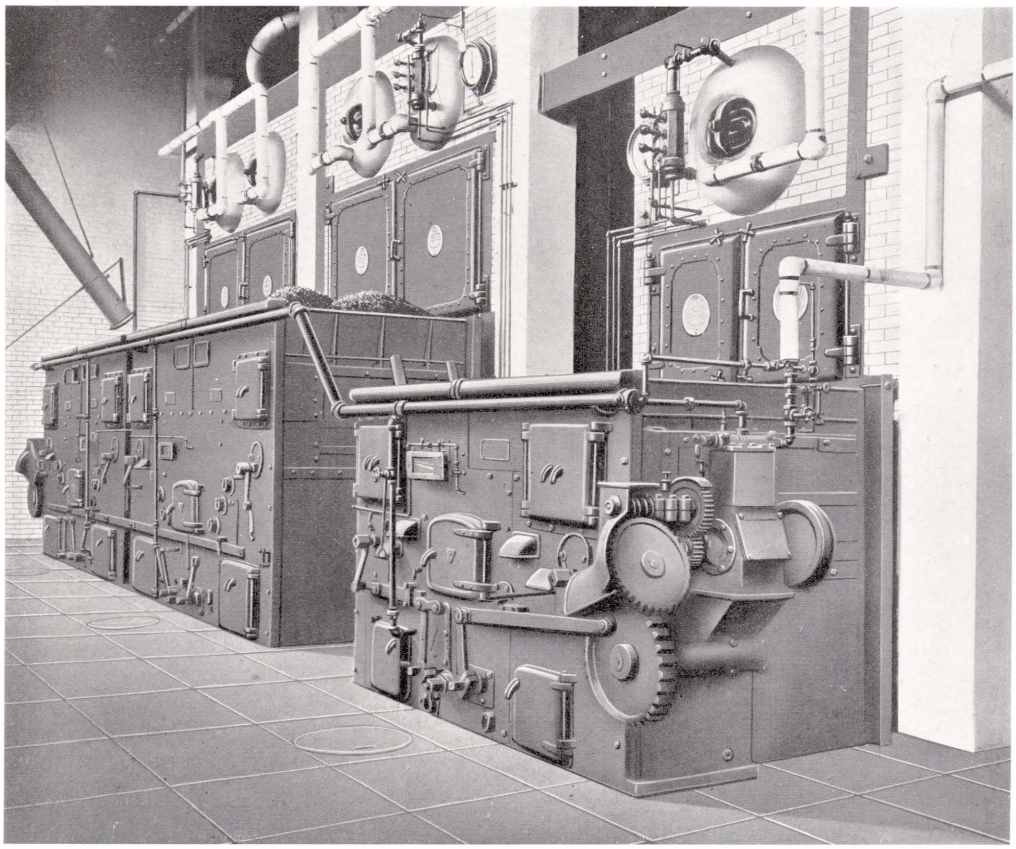
Keeler headers are eight inches deep inside, all open, and the throats where they are connected to the shell extend practically halfway around the circle, making an opening for the free passage of water greatly in excess of that provided in many other designs.

It is not possible by any arrangement of tubes and drums to secure any greater benefits of circulation than provided in the arrangement of the Keeler Boiler.



BOWEN HIGH SCHOOL, SOUTH CHICAGO, TWO 300 H. P. BOILERS.
DOWN DRAFT FURNACES.

A good circulation will keep tubes continually full of water, so that the transfer of heat is not interrupted by the presence of steam to the exclusion of water. A good circulation will aid in the production of dry steam; will prevent unequal expansion and destructive internal strains; will prolong the life and reduce repairs to a minimum. Circulation should begin as soon as the fire is started and by a constant, unimpeded flow should keep all parts of the Boiler at practically the same temperature. A good circulation will tend to hold mud and scale forming substances in suspension until they reach the rear header and drop below the lowest row of tubes to be discharged through the blow-off pipe which is tapped into the lowest point of the boiler. A good circulation will increase the efficiency of the heating surface by constantly bringing cooler water in contact with surfaces at high temperature. A good circulation will permit forcing the boiler to a greater percentage of overload without loss of economy. A good circulation will prevent the burning out of tubes.

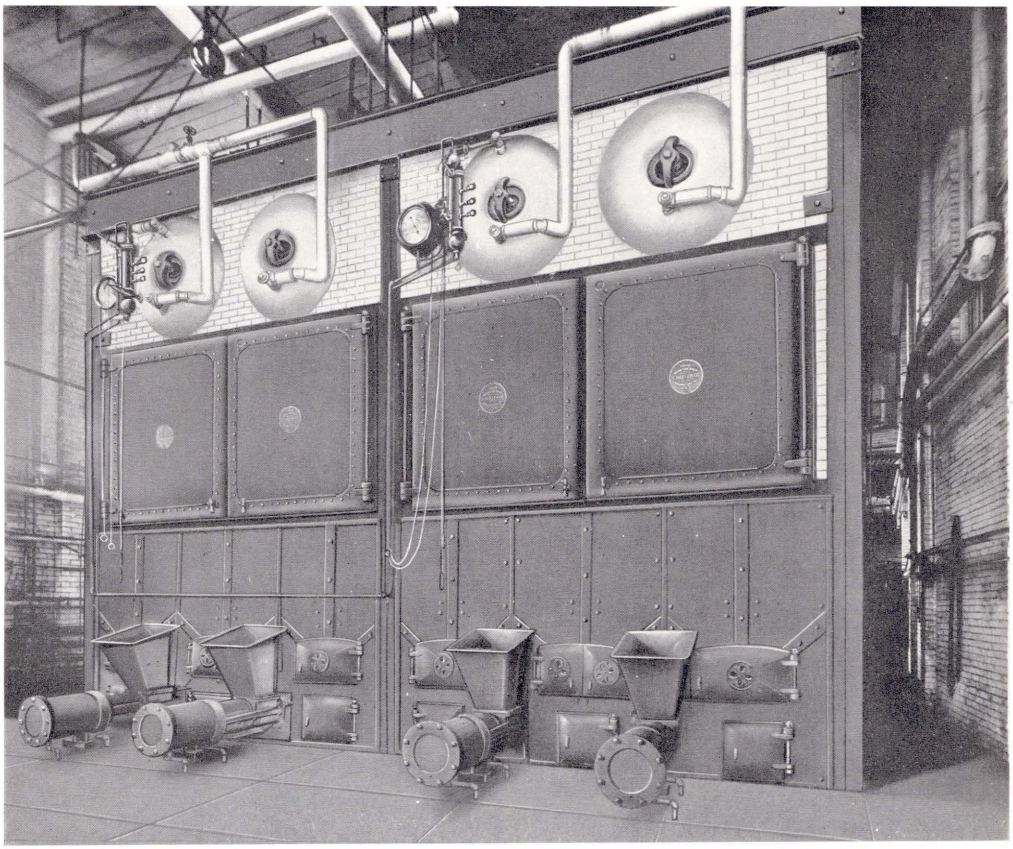


FRANKFORD HIGH SCHOOL, PHILADELPHIA, PA., TWO 300 AND ONE 100 H. P. BOILERS.

Requirements of a Modern Steam Plant

The economy of high pressure steam has been most thoroughly demonstrated. In order to reap the benefits of compounding, steam should be maintained at not less than 150 pounds pressure, and for the triple and quadruple expansion engines of large central stations, still higher pressures are an absolute necessity if the most economical performances are to be attained. The higher the pressure carried, the greater the power developed by a given engine or in a given space. The steam turbine, rapidly increasing in public favor, also requires high pressure steam for economical working, and boilers for turbine plants are usually built for working pressures up to 200 pounds.

For ordinary mill or factory service where steam at 100 pounds is required, it is well to have a boiler plant that can be depended on to furnish steam at this pressure continuously. The pressure allowed a return tubular boiler decreases with the term of its service.



FELS & CO., PHILADELPHIA, PA., TWO 500 H. P. BOILERS.
UNDERFEED STOKERS.

The water tube boiler with its quick steaming properties and great capacity for overload has been generally adopted by electric and heavy duty power plants, and wherever the demand for steam is sudden and intermittent.

The modern steam plant requires a boiler that shall combine the highest efficiency and capacity with absolute safety and reliability under the severest strains of high pressure steam. These requirements are met by the Keeler Water Tube Boiler. By reason of the *all steel* construction of headers, drums, etc., the Keeler Water Tube Boiler can readily be designed for the highest pressures required by modern practice.

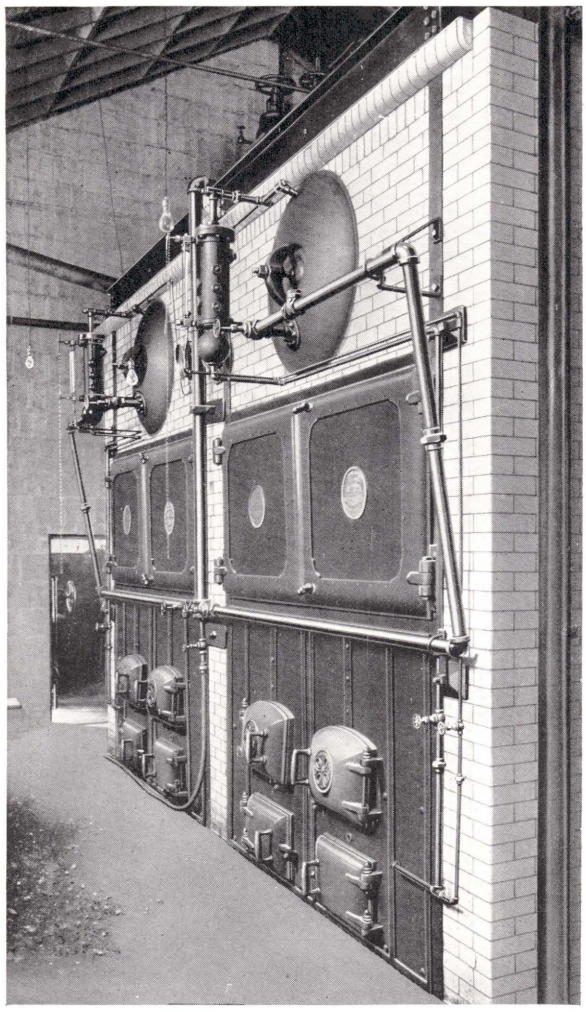
THE COMPARISON

For the purpose of comparison add to the price of any bent tube boiler the cost of an adequate stock of each different style of tube in the boiler. This stock is a portion of the necessary equipment and should be charged to first cost since it must always be maintained. The cost of entirely retubing the boiler will be found an important consideration in some localities.

Add to the cost of any boiler shipped in a knocked down condition with the services of an erecting engineer only, the difference in amount of labor required to assemble and test the boiler and place it in position ready for brick work.

Add to the cost of any vertical boiler the very much greater cost of building to receive it, the increased labor and risk of placing it in an upright position and the difference in cost of brick setting.

The brick setting of a horizontal water tube boiler requires a smaller quantity of materials for units of the same capacity. Further the labor of placing these materials is less because the setting is lower.

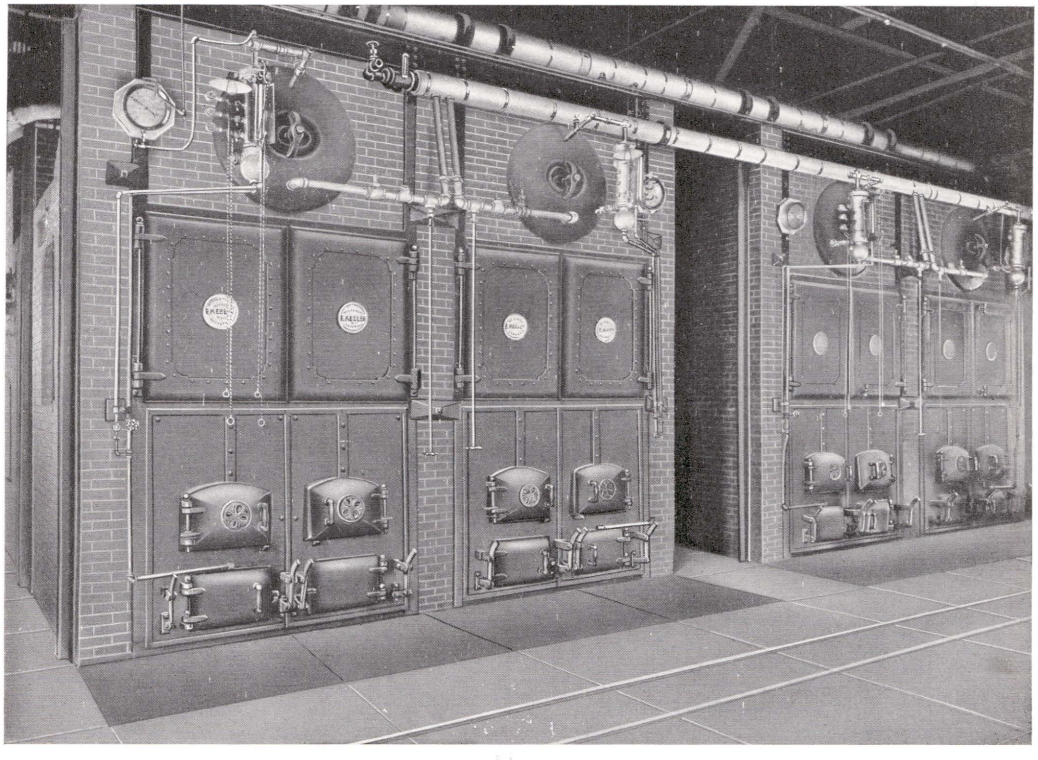


CUMBERLAND BASIN COAL CO., BARRELVILLE, MD., TWO 220 H. P. BOILERS.

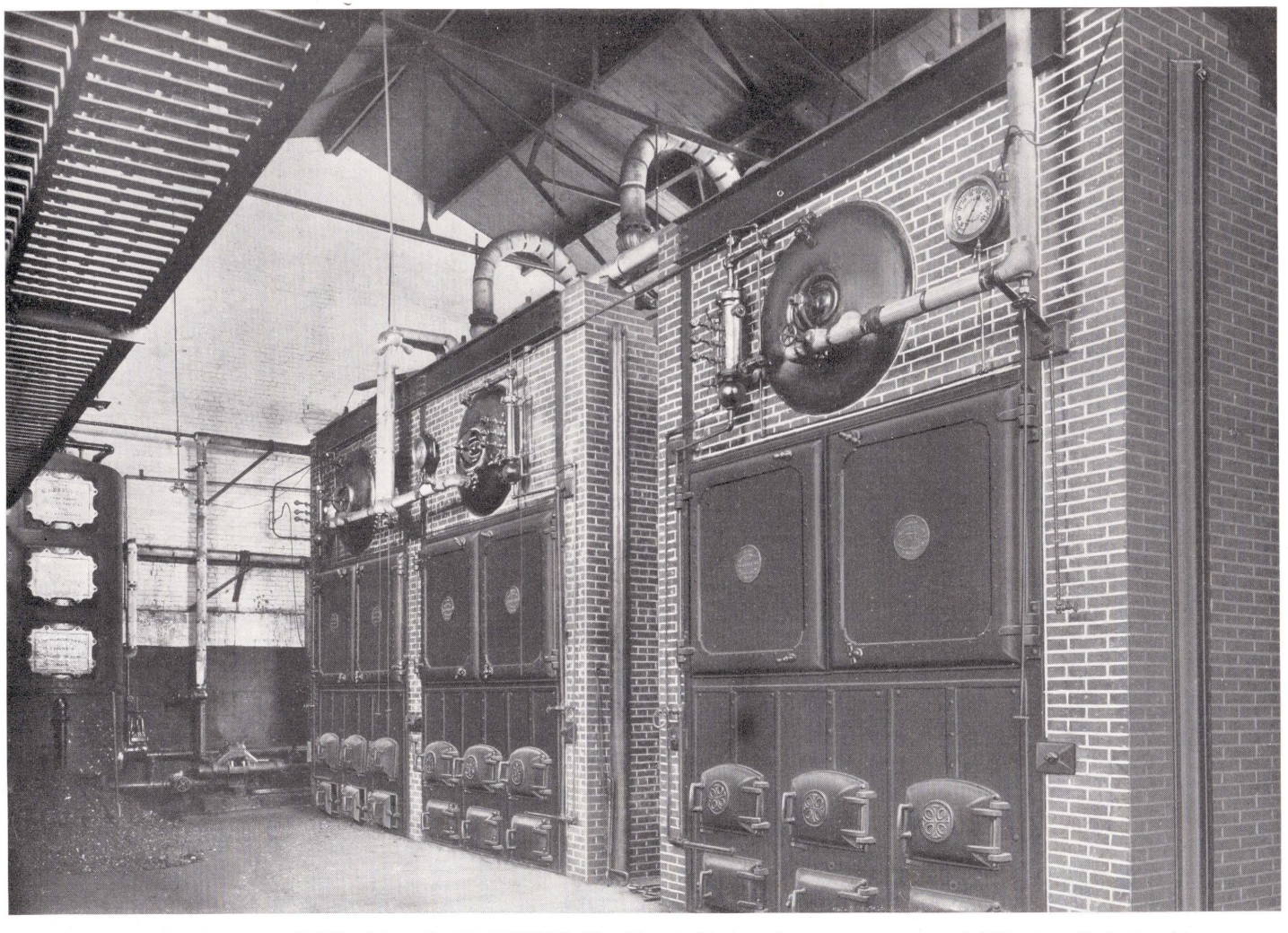
The horizontal water tube boiler completely assembled and tested at the shop can always be erected and bricked in, in less time than any other type. Add the cost of each additional day's idleness of the factory while waiting for steam to the cost of any vertical boiler or any boiler shipped in a knocked down condition.

When the above considerations are given their correct values it will be found that the first cost of a more efficient and more dependable boiler is so close to the cost of less desirable equipment that the very much more important considerations of operation and maintenance will make the selection of a horizontal, straight tube, wrought steel boiler imperative.

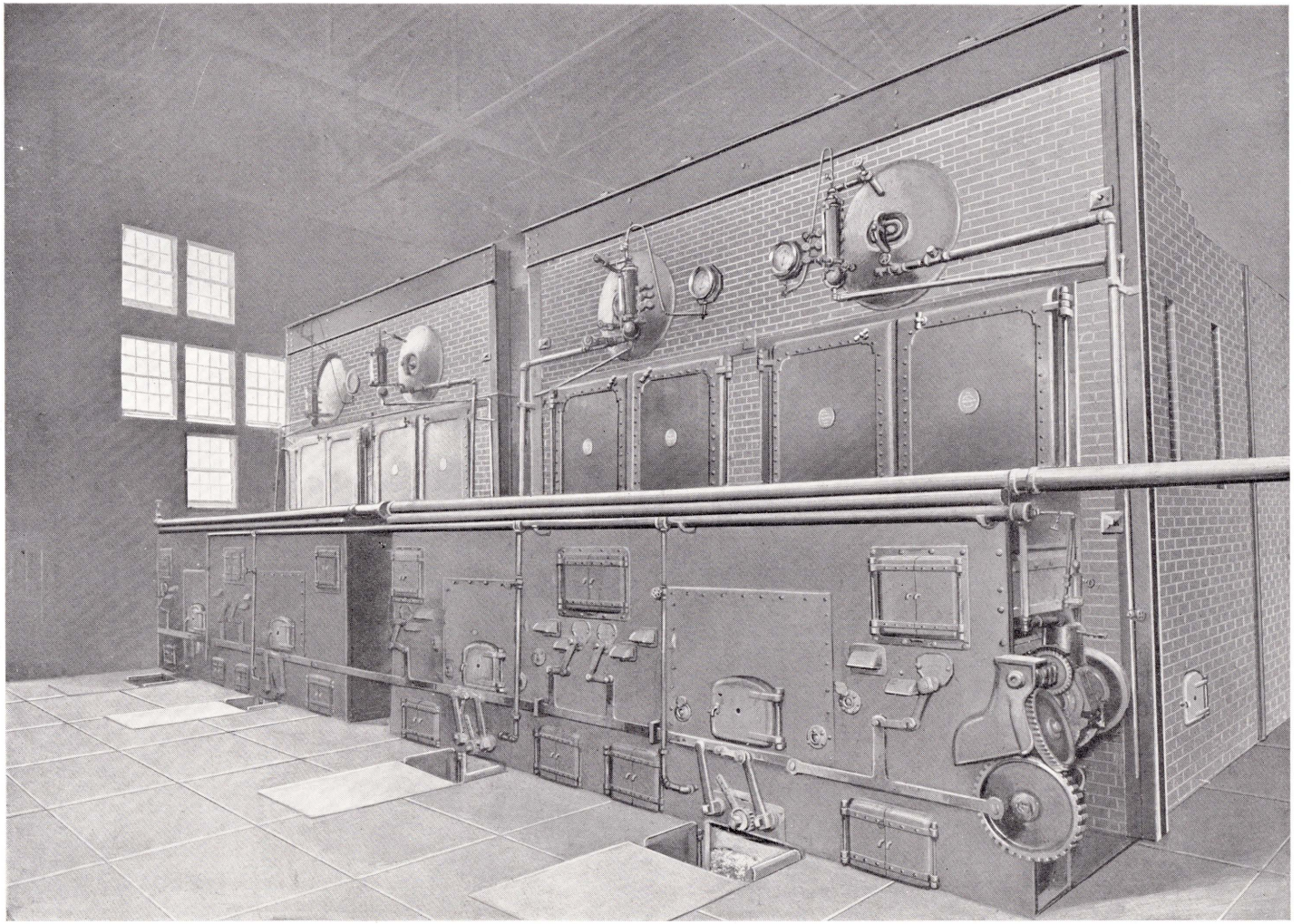
SHIPMENT OF TWELVE 410 H. P. BOILERS AT PORT RICHMOND, PA., FOR GATUN AND MIRAFLORES, CANAL ZONE. EQUIPPED FOR OIL FUEL.



UNITED STATES ARMORY, SPRINGFIELD, MASS., FOUR 200 H. P. BOILERS.



NORTHUMBERLAND COUNTY GAS AND ELECTRIC CO., MILTON, PA., THREE 300 H. P. BOILERS INSTALLED 1910. ONE 300 H. P. BOILER INSTALLED 1911. TWO 500 H. P. BOILERS INSTALLED 1916.



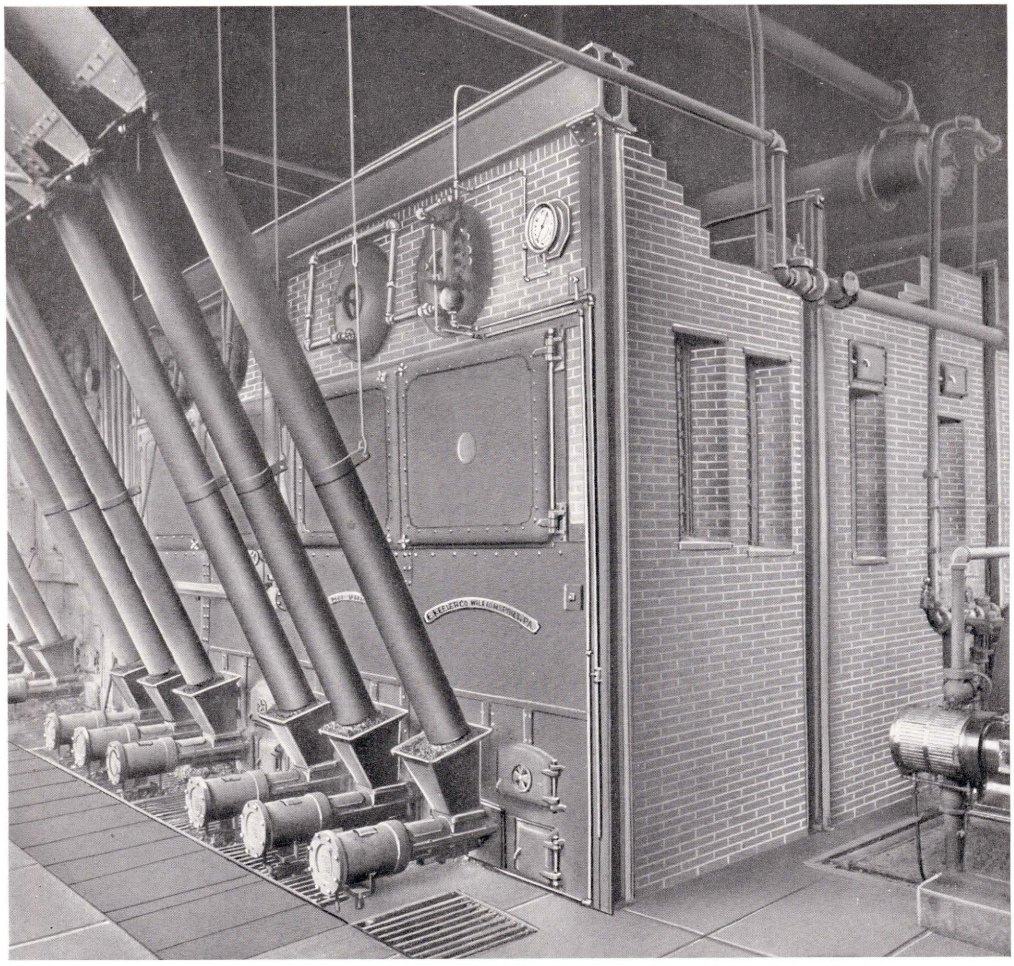
CAYUGA LAKE CEMENT CO., ITHACA, N. Y., THREE 300 H. P. BOILERS. A FOURTH BOILER SET IN KEELER SUSPENSION FRAME AND FRONT.

TESTS OF KEELER WATER TUBE BOILERS

LOCATION	Gatun Handling Plant, Gatun Locks, C. Z.	Miraflores Handling Plant Miraflores Locks, C. Z.	United States Naval Sta. Key West, Fla.	United States Bureau of Standards, Washington, D. C.	Pennsylvania State Capitol	Susquehanna Iron Co. Columbia, Pa.
Engineer	Testing Dept. Mechanical Div.	Testing Dept. Mech. Div.	Eng. Dept. E. Keeler Co.	S. Franklin Gardner	Senior Class Pa. State College	Geo. H. Bayne
Kind of Fuel	Pocohontas Coal Run of Mine	Pocohontas Coal Run of Mine	W. Va. Co. Run of Mine Semi. Bit.	Anthracite No. 1 Buckwheat	Shamokin Anthracite Pea	Webster Semi Bituminous
Kind of Furnace	Hand Fired Ajax Shaking Grates	Hand Fired Ajax Shaking Grates	Hand Fired	Hand Fired Ajax Shaking Grates	Plain Grates	Plain Grates
Grate Surface, Sq. Ft.	68.5	68.5	45	63	4 Boilers, 168	3 Boilers, 123.75
Heating Surface, Sq. Ft.	4089	4089	2043	2526	4 Boilers, 7724	3 Boilers, 7500
Duration of Trial, Hours	10	8	8	18	20	5
Wt. Coal as Fired, Lbs.	16,811	12,545	8,936	19,380	60,463	12,594
Moisture in Coal, Per Ct.	4.17	1.78	1.2	6.6	6.835	1
Wt. Dry Coal, Lbs.	16,110	12,321.69	8,830	18,101	56,330	12,468
Wt. Ash and Refuse, Lbs.	283.5	316.50	840	4904	12412	1007.5
Percentage Ash in Dry Coal	1.76	2.56	5.8	27.00	22.00	8.00
Total Water, Lbs.	163,744	129,218	868.72	130,772	439,997	123,425
Water Evaporated, Corrected for Moisture, Lbs.	Superheated	Superheated	85,786	130,249	427,677	121,080
Factor Evaporation	1.1378	1.1391	1.14	1.2168	1.077	1.112
Equivalent Evaporation from and at 212 Deg. F., Lbs.	186,308	147,192	97,696	158,487	460,608	134,641
Dry Coal per Sq. Ft. Grate per Hour, Lbs.	23.52	22.48	24.53	15.96	16.8	20.1
Equivalent Evaporation per Sq. Ft. of Heating Surface per Hr., Lbs.	4.55	4.5	4.78	3.48	2.98	3.59
Steam Pressure, Lbs.	193.24	188.06	135.6	121.05	80.66	86.5
Temperature of Feed Water, Deg. F.	189.5	183.57	122	42.8	172.4	140
Temperature of Escaping Gases, Deg. F.	488.62	473.62	530	461.57	440.06	515
Draft in Uptake, In.	.836	.412	.78	.878	.318	.3
Per Cent. of Moisture in Steam	Entering Superheater 1.336		1.25	.004	2.8	1.9
No. Degrees of Superheat	106.81	98.79	0	0	0	0
Horse Power Developed	540	533.3	356.8	255	667.54	780.52
Rated Horse Power	410	410	204	253	772	750
Percentage of Rated H. P. Developed	131	130	174.6	100.7	86.5	104
Equivalent Evaporation from and at 212 Deg. F. per Lb. Dry Coal	11.56	11.946	11.64	8.755	8.17	10.79
Equivalent Evaporation from and at 212 Deg. F. per Lb. Combustible	11.77	12.26	12.22	12.01	10.48	11.74

TESTS OF KEELER WATER TUBE BOILERS

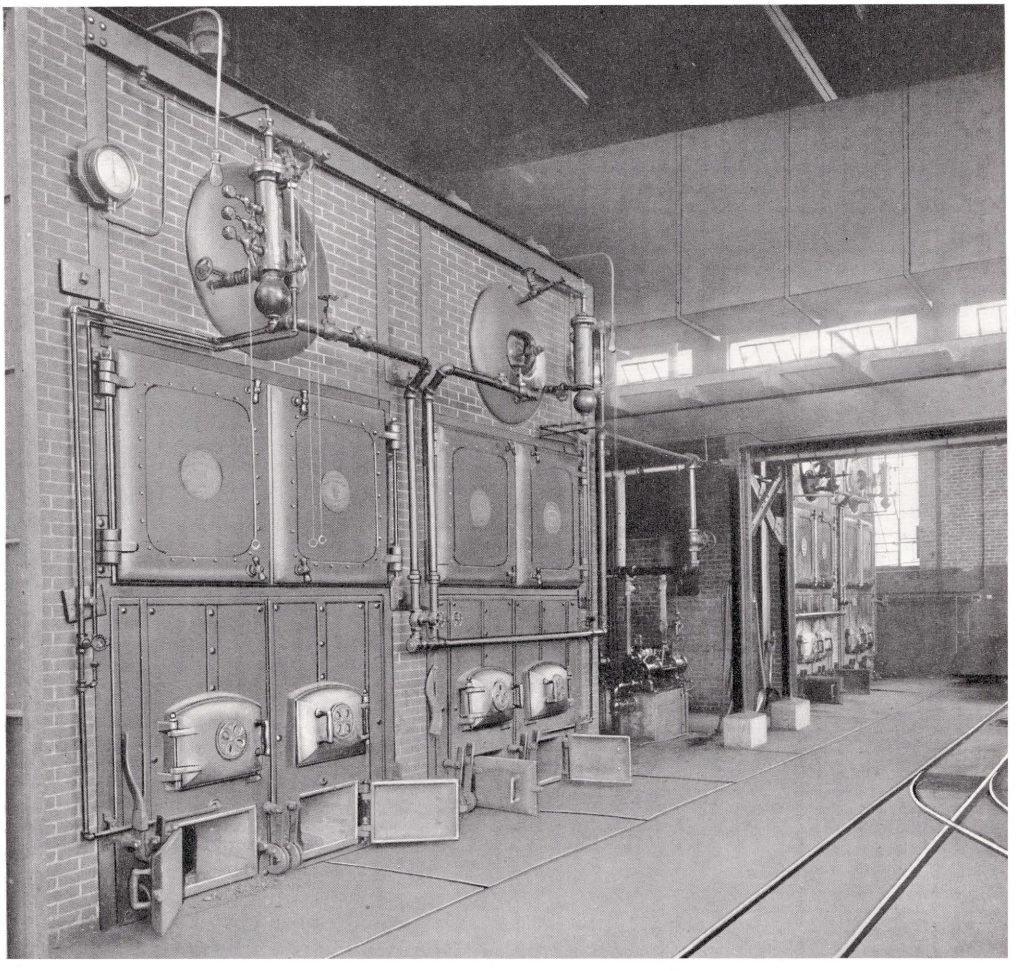
LOCATION	West Chester Street Ry. Co. Lenape, Pa.	J. K. Mosser Co. Williamsport, Pa.	Davis Coal & Coke Co. Thomas, W. Va.	Lycoming Edison Co. Williamsport, Pa.	Lycoming Edison Co. Williamsport, Pa.	Absecon Pumping Station, Atlantic City, N. J.
Engineer	Jay M. Whitham	Jay M. Whitman	M. D. Kirk	R. C. Carpenter	R. C. Carpenter	
Kind of Fuel	Mahanoy Anthracite 2 Buckwheat	Beech Creek Semi-Bituminous	Bituminous 50% Nut 50% Pea Slack	Anthracite 2 Buckwheat	Clearfield Bituminous	Anthracite
Kind of Furnace	Hand Fired	Dutch Oven Hand Fire	Jones Underfeed Stokers	Roney Stoker	Roney Stoker	Hand Fired Ajax Shaking Grates
Grate Surface, Sq. Ft.	2 Boilers 104	2 Boilers 162	1 Boiler 80	2 Boilers 150	2 Boilers 150	44
Heating Surface, Sq. Ft.	2 Boilers 5000	2 Boilers 6000	1 Boiler 5000	2 Boilers 6308	2 Boilers 6308	2000
Duration of Trial, Hours	8	8	8	11	10	5
Wt. Coal as Fired, Lbs.	13,086	18,000	13,135	24,311	22,119	3,050
Moisture in Coal, Per Ct.	6.5	4.4	.58	1.92	1.73	
Wt. Dry Coal, Lbs.	12,236	17,208	13,049	23,844	21,736	
Wt. Ash and Refuse, Lbs.	2,062		3,018	4,046.5	2,424	425
Percentage Ash in Dry Coal	16.85		23.	16.97	11.15	14
Total Water, Lbs.	107,904	171,028	123.891	204,420	210,112	28,750
Water Evaporated, Corrected for Moisture, Lbs.			122.652	Superheated	Superheated	
Factor Evaporation	1.0533	1.0478	1.06115	1.0956	1.097	1.092
Equivalent Evaporation from and at 212 Deg. F., Lbs.	113,655	179,203	130,134	223,963	230,493	31,395
Dry Coal per Sq. Ft. Grate per Hour, Lbs.	14.7	13.2	20.39	14.45	14.5	13.9
Equivalent Evaporation per Sq. Ft. of Heating Surface per Hr., Lbs.	2.84	3.74	3.25	3.23	3.65	3.14
Steam Pressure, Lbs.	112.6	112.9	147.7	188.7	187.7	105
Temperature of Feed Water, Deg. F.	200.5	205.8	197.0	202.4	205.3	161.3
Temperature of Escaping Gases, Deg. F.	416			438 428	472.9 436.0	
Draft in Uptake, In.	Forced Draft .94 Ash Pit	.96		.63	.69	
Per Cent. of Moisture in Steam						
No. Degrees of Superheat	0	0	0	55.5	64.1	0
Horse Power Developed	411	650	472	590	668	182
Rated Horse Power	500	600	500	630	630	200
Percentage of Rated H. P. Developed	82	108	94.4	94	106.	91
Equivalent Evaporation from and at 212 Deg. F. per Lb. Dry Coal	9.29	10.41	9.42	9.39	10.6	Coal as Fired 10.29
Equivalent Evaporation from and at 212 Deg. F. per Lb. Combustible	11.17		12.20	11.31	11.94	11.96



DAVIS COAL & COKE COMPANY, THOMAS, W. VA., TWO 500 H. P. BOILERS.
UNDERFEED STOKERS.

PROGRESS

A progressive policy and a constant study of operating conditions have resulted in a gradual evolution of fixtures. Every detail has been subjected to critical observation with the object of producing equipment perfectly suited to the requirements, that could be depended upon for many years of service.



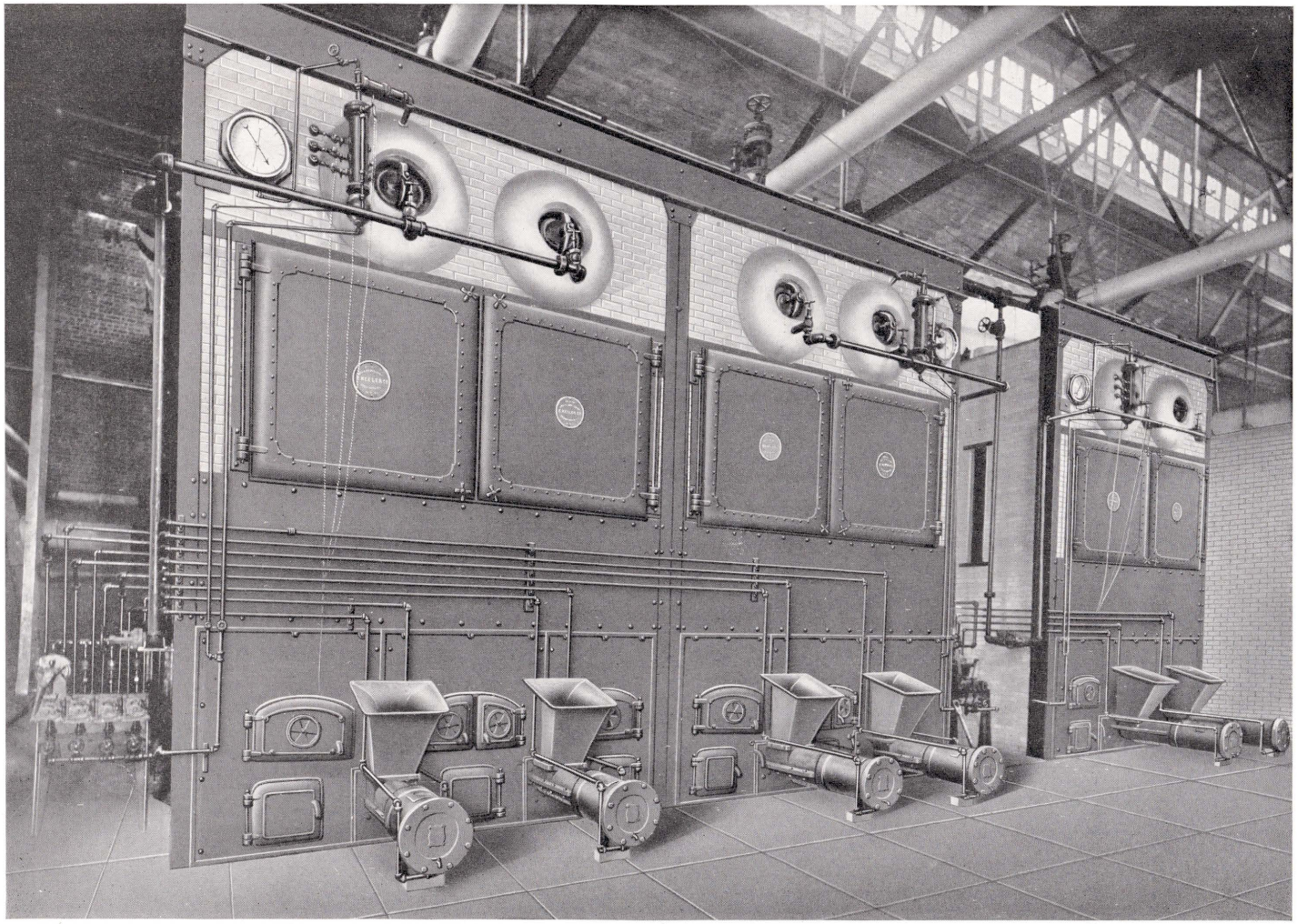
UNITED STATES ARSENAL WATERTOWN, MASS., THREE 185 H. P. BOILERS INSTALLED 1912. ONE 185 H. P. BOILER INSTALLED 1914. FOUR 185 H. P. BOILERS INSTALLED 1915.

1864—FIFTY-THIRD YEAR—1916

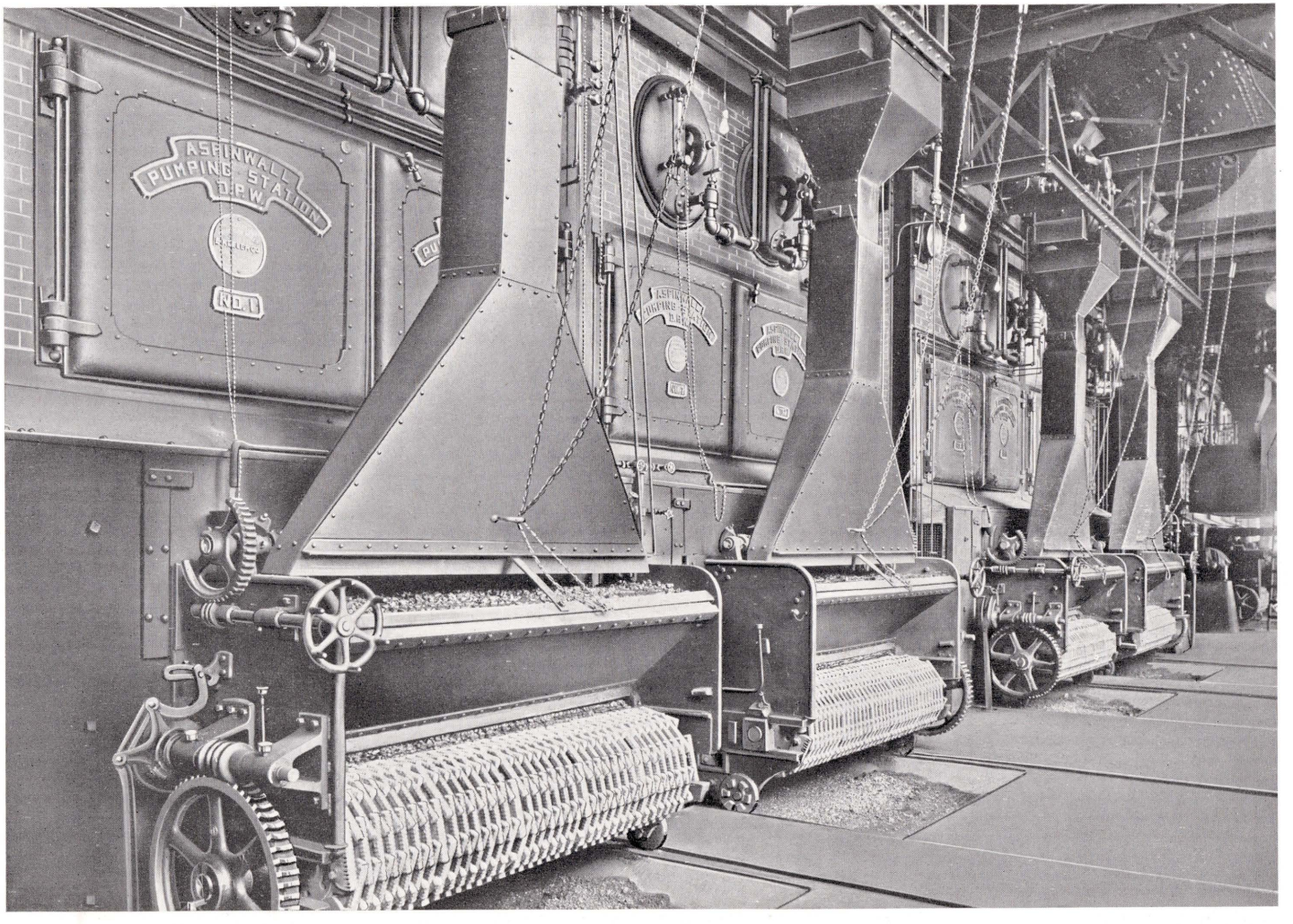
The E. Keeler Company was established in 1864 and has been continuously engaged in the manufacture of boilers for power purposes since that time. The location of the plant has never been changed.

The value of these two facts to the purchaser of boilers lies in the stability of a business of fifty-three years growth, and the rich accumulation of experience and ideals.

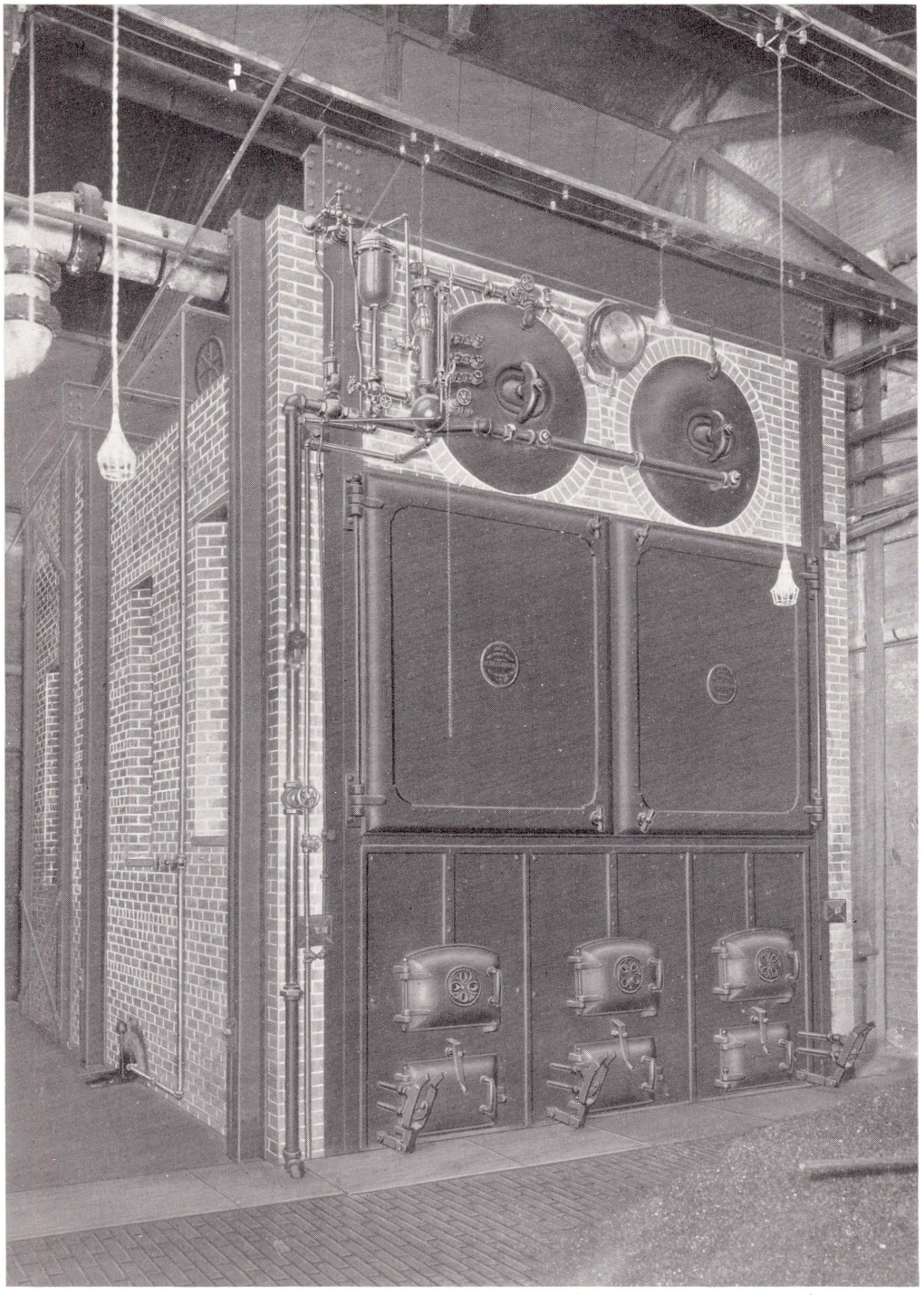
The best guarantee that a purchaser can secure is to place his work in a shop which maintains a standard of workmanship uniformly high. It is the practice of the E. Keeler Company to make every boiler built in its shop an example of a workmanship that is second to none.



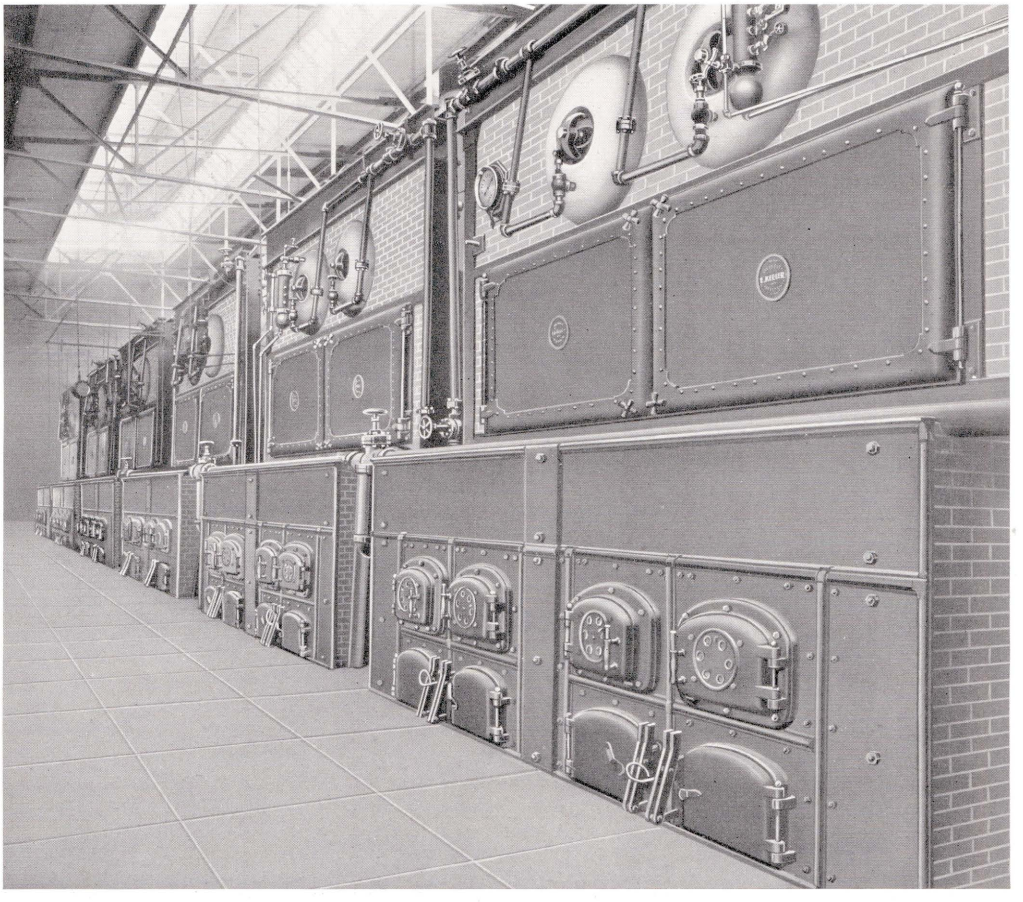
LONG ISLAND STATE HOSPITAL, LONG ISLAND, N. Y., THREE 401 H. P. BOILERS. UNDERFEED STOKERS.



ASPINWALL PUMPING STATION, CITY OF PITTSBURGH, PA., WATER DEPARTMENT, SIX 292 H. P. BOILERS.
CHAIN GRATE STOKERS.



WARNER CHEMICAL COMPANY, CARTERET, N. J., ONE 504 H. P. BOILER INSTALLED 1911. TWO 241 H. P. BOILERS INSTALLED 1914. ONE 375 H. P. BOILER INSTALLED 1915.



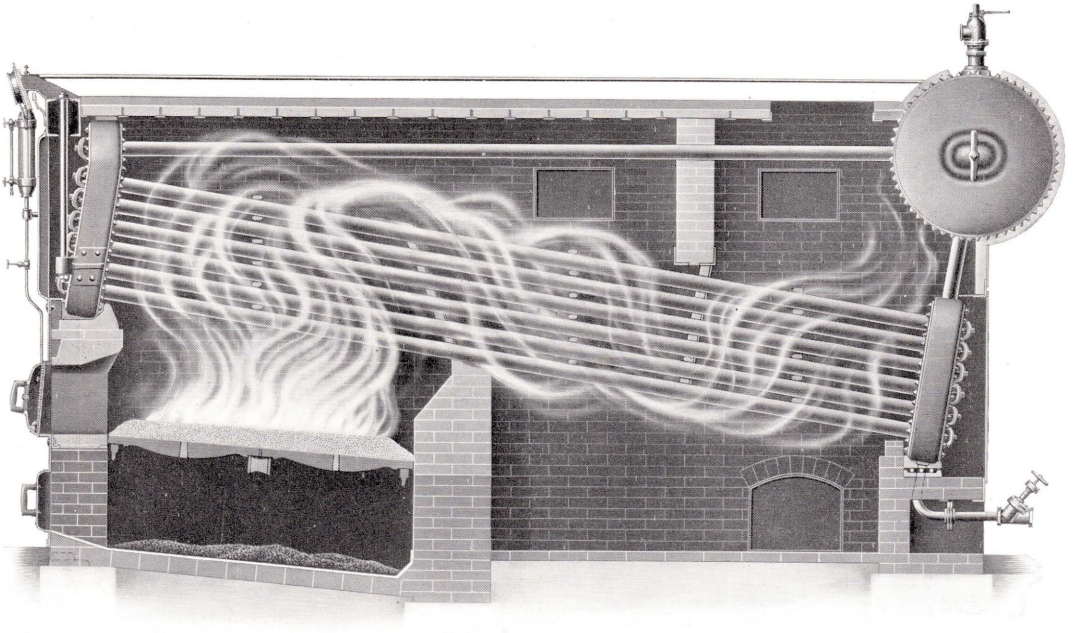
LUZERNE COUNTY GAS AND ELECTRIC CO., PLYMOUTH, PA., ONE 500 H. P. BOILER INSTALLED 1911. ONE 500 H. P. BOILER INSTALLED 1912. TWO 500 H. P. BOILERS INSTALLED 1913. TWO 500 H. P. BOILERS INSTALLED 1914. TWO 603 H. P. BOILERS INSTALLED 1915. BOILERS WITH DUTCH OVEN FURNACE FOR BURNING CULM.

Believing always in the demand for the very best, it is this company's fixed policy to offer only what will surely prove satisfactory and enduring.

Many details must be left to the intelligence of the builders. If an installation as a whole is to be a success, each component part must be good in design and execution. Painstaking attention to the smallest requirements is the foundation of the wide reputation of Keeler Quality.

The service rendered by Keeler Water Tube Boilers under all conditions is a matter easily investigated. Such investigation will show a general reliability of all parts, resulting in either no repairs at all, or repairs limited almost without exception to the replacing of tubes.

The Keeler Water Tube Boiler, Cross Drum Type



The Keeler Cross Drum Water Tube Boiler is a modification of the standard design only in the length and location of the drum and the method of connecting it to the headers.

This type was developed to meet the demand for a high pressure water tube boiler that could be installed in boiler rooms where ceiling height is limited or where the boiler must be introduced through narrow passageways or restricted openings.

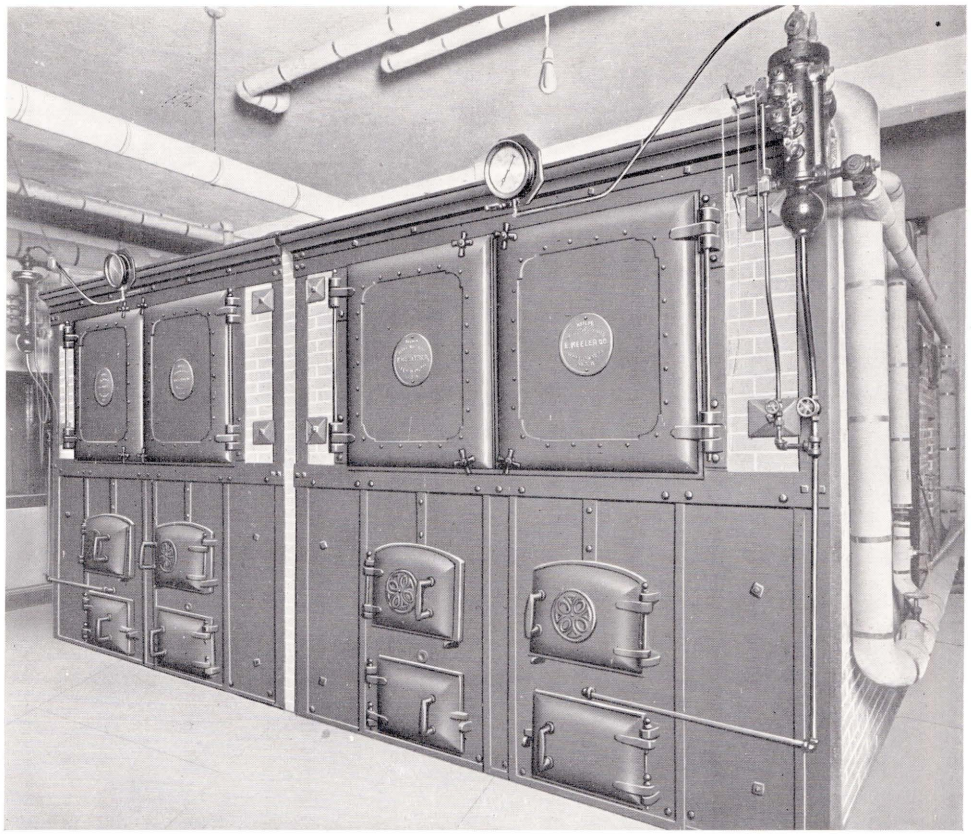
The pressure parts of the boiler are shipped in a knocked down condition, making it possible to install it without cutting through walls and floors in locations that would be wholly inaccessible for almost any other type of boiler.

If boilers are to be exported, the cross drum boiler can be handled at much less expense by steamship companies on account of its reduced bulk in a knocked down condition, and the comparatively small weight of the heaviest piece.

If boilers must be hauled to destination over difficult roads or over bridges of limited capacity this boiler meets all requirements.

The drums and headers are thoroughly tested under hydrostatic pressure before shipment. There are no rivets to be driven in the field, all joints being made by expanding tubes into accurately drilled holes.

While the Cross Drum Boiler may be erected by any mechanic familiar with water tube work, we are prepared to send erecting engineers of large experience with this boiler to any part of the country.



FORD BROTHERS BUILDING, GREAT FALLS, MONT., TWO 150 H. P. CROSS DRUM BOILERS.

The Cross Drum Boiler presents the same features of simplicity, durability, safety and economy which characterize the standard design. The boiler is of strictly all wrought steel construction and materials and workmanship are the same in every detail.

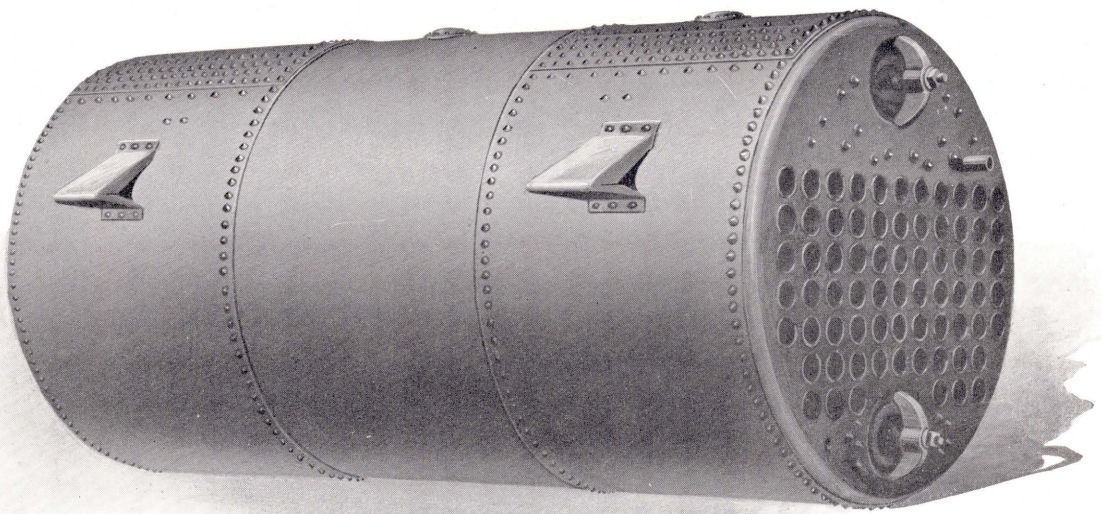
Wrought steel for the pressure parts of a water tube boiler even for low pressure service is recognized as the only dependable material. Cast iron headers are as liable to crack through unequal expansion of tubes as from internal pressure. Failures of cast iron headers have occurred in filling with cold water a boiler which was still warm.

All parts of this boiler are equally as accessible for inspection and cleaning as the standard type. The removing and replacing of tubes is a simple process. There is no other part of the boiler likely to require repairs even after many years of service.

There is no detail of this boiler that is in any way experimental. The headers are designed with the flanged wrapper sheet which has proven an acceptable feature of the standard type since its first introduction. Stay bolts, diameter and spacing of tubes, hand-hole plates and yokes are identical.

A full description of this boiler will be found in our book "Cross Drum Boilers," which will be sent on request.

THE KEELER RETURN TUBULAR BOILER



The Return Tubular Boiler occupies a field of its own where it is undoubtedly as good a boiler for the purpose in view as can be selected. We have succeeded in bringing the design of this boiler to the highest degree of perfection. The features of the boiler described as our standard have been adopted for the purpose of securing dependability and eliminating weaknesses and defects.

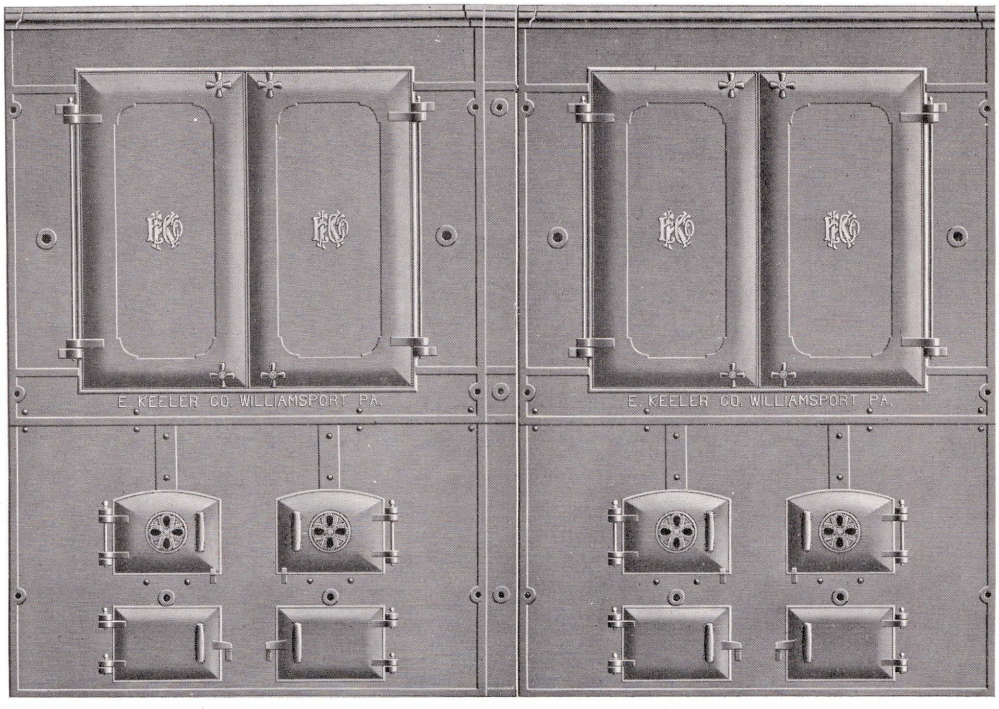
Keeler Boilers, 16 feet long and over, are built in three courses, with the middle course lapping inside of the end courses, and both heads the same size. This construction avoids the unequal internal strains inseparable from long riveted seams, which are a feature of boilers, built with bottom half in a single sheet. The girth seams add greatly to the stiffness of the shell.

The manhole plates, yokes and brackets are of pressed steel. The steam outlets and safety valve outlets are dropped forged steel nozzles or extra heavy pressed steel flanges.

The longitudinal seams except on boilers for low pressure heating purposes only, are built with butt straps and are double, triple or quadruple riveted as required by the size and pressure.

The tube holes are drilled from the solid plate. All rivet holes are made $\frac{1}{4}''$ smaller than required and drilled to size. The burs are removed before riveting and each rivet hole is perfectly clean and in line before rivets are driven.

CASTINGS AND FIXTURES



STANDARD FULL FLUSH FRONT FOR BATTERY.

Keeler Full Flush front is of heavy, substantial design. All doors have a deep flange or roll. This feature prevents warping and cracking of edges and gives the front a rich and handsome appearance. The fire doors are of extra heavy deep pattern with a liberal air space between the door and perforated liner which preserves both castings. Fire doors close against inclined seats so that they never hang away from the front. Provision is made for expansion above the fire doors, which absolutely prevents cracks at the corners of the openings under all ordinary conditions of service. All doors are fitted to a close bearing, and all fronts are assembled complete before shipment. The top of the front is furnished with a handsome cornice.

The tube door latch is provided with a threaded handle turning on a tee headed bolt. When the handle is revolved the bolt draws the latch against the inside of the front. This latch is so powerful in its action as to entirely prevent the tube door from warping and standing away from its seat with consequent loss of draft and efficiency.

Dead plates are of a special design arranged for fire brick lining. This keeps the fire away from the dead plate and prevents it from burning. Ribs alternate with the brick and prevent excessive wear.

A full description of this boiler will be found in our book "Return Tubular Boilers," which will be sent on request.

WEST STREET BUILDING, NEW YORK CITY.
FOUR 250 H. P. KEELER BOILERS.

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